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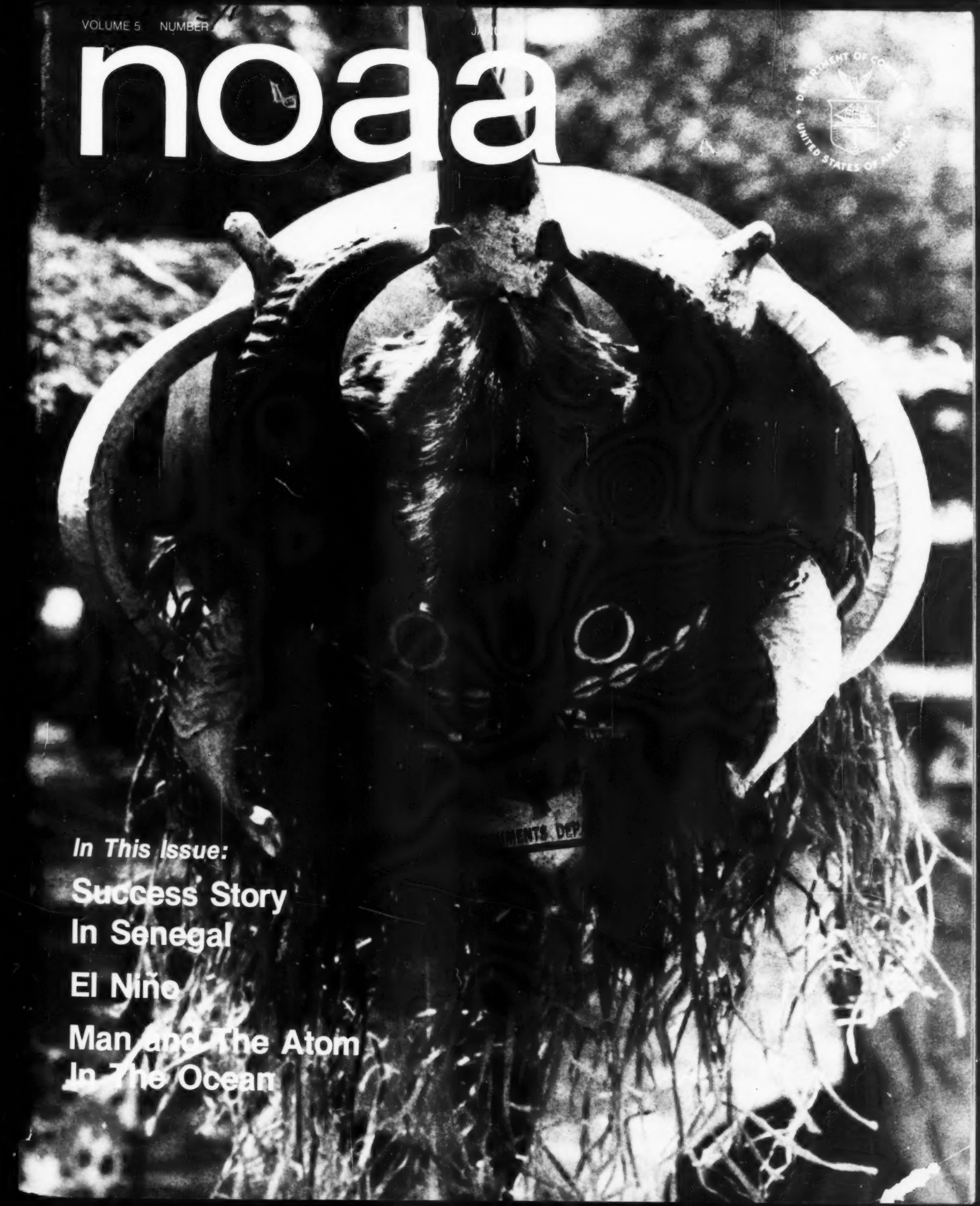

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COVER: Dramatic Senegalese masks were familiar sights to participants in GATE (Page 24).

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A Message From the Administrator

Robert M. White

Last year's energy crisis, while spectacular, was but a harbinger of things to come; today it has become a full-fledged matter of national urgency to find and develop new energy resources.

This in turn has generated a major running debate. Some would produce energy at any cost; others would place environmental quality before energy, still others seek the proper balance.

Let me restate my conviction that this Nation can develop new energy resources, and it can preserve its environmental aspirations. We are aware that energy will be obtained at a price. Whether we wish to pay it, or what part we wish to pay, can be decided rationally only if we know what the price is.

This is where NOAA has a major role in the energy problem—serving the Nation by substituting solid information for emotion, light for heat, so that intelligent choices may be made.

Activities that support our energy needs are very high on NOAA's priority list; the opportunity to serve our nation in this regard is unique indeed. It is for this reason we have placed such emphasis on rapid implementation of the Coastal Zone Management Act of 1972. Our Coastal Zone Management office has performed magnificently, with 29 of 30 coastal states now preparing comprehensive plans which can accommodate the onshore impacts of oil and gas development of the continental shelf—rationally. It gave me great pleasure recently to be present when President Ford announced intensified coastal zone management activities as a necessary adjunct to offshore energy development.

A top priority has also been placed on getting NOAA's fleet back into the water. In the past Congress, funds were provided to return three NOAA vessels to service to help achieve the environmental and baseline assessments necessary to development of our continental shelf gas and oil resources. The National Ocean Survey has responded wonderfully. Finding people to man these ships has required quick reassignment of many of our NOAA Commissioned Corps. The disruption to our officers and their families is substantial. We are all proud that NOAA's Commissioned Corps can respond so rapidly and well to a national need.

Environmental assessment involves every part Of NOAA—none of our agencies or offices is untouched by it. Our Research Laboratories, our Fisheries Service, our Data Service, our Weather Service and Sea Grant Program have key roles. We have developed close working relationships with our sister agencies, the Bureau of Land Management and the Geological Survey to carry out this national effort. This is the kind of mission for which NOAA was created, one with relevance, immediacy, and urgency. I know we will not disappoint those who are looking for the answers to questions of national importance.

Robert M White

Man and the Atom in the Ocean

BY KURT STEHLING

The ocean, increasingly used by nuclear power plant engineers for stationary and ship power generation, is becoming a laboratory for other types of atomic scientists as man begins to match the arcane techniques of high-energy physics and radio-chemistry to the undersea environment. This evolution of the atom in the ocean may hold profound implications for ecologists, marine geologists, and high energy physicists.

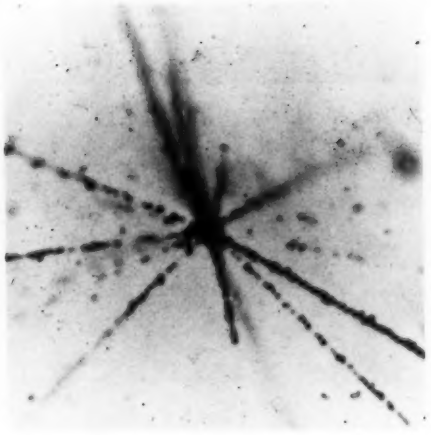
Reactors first went to sea in 1954 in the nuclear-powered submarine *Nautilus*. Many have followed aboard some surface ships and in the swift nuclear submarines of three of the world's major powers. Nuclear aircraft carriers and other naval vessels and nuclear merchantmen, icebreakers and the like are no longer experimental curiosities. Now there is active planning to put nuclear power reactors off-shore in shallow oceanic sites, away from population centers, surrounded by the natural ocean coolant. Present plans envision floating reactor complexes surrounded by an energy-absorbing man-made breakwater, capable of withstanding the harsh weather and water of the ocean, from hurricanes to submarine earthquakes. Alternative plans see fixed offshore installations, standing on long, rigid legs driven into the ocean floor.

While nuclear engineers preoccupy themselves with developing the reactors, scientists with NOAA, the AEC and other organizations are concerned with the problems of siting or mooring these power complexes, and predicting their probable ecological impact. And now, in an interesting closure of the investigative circle, scientists are using nuclear tracing techniques to examine the seafloor, which must eventually become home for these massive installations.

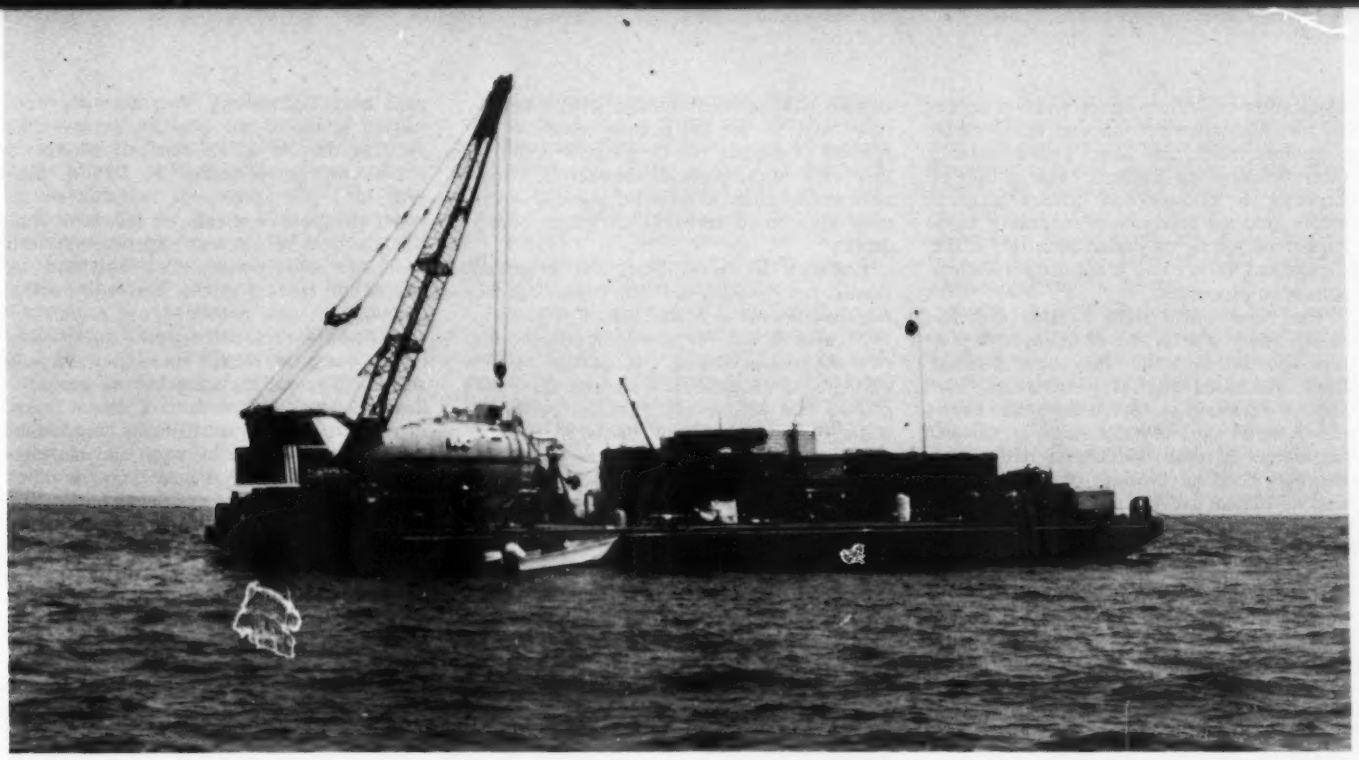
Physicists and radio-chemists—who deal with radioactive substances—know that interactions between nuclear and sub-nuclear particles may emit radiation which might be used to identify the target nuclear species. For example, when neutrons—the energetic, uncharged constituents of all atomic nuclei except hydrogen—bombard another nucleus, they disturb it enough so that it emits gamma radiation. The electro-magnetic gamma radiation yields spectra characteristics of the nucleus. The spectra emitted provide a radiological signature of the element being bombarded.

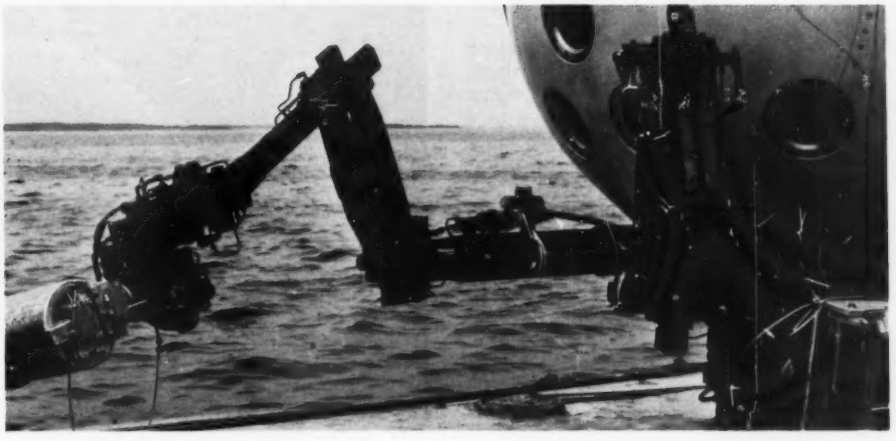
Thus, by neutron illumination, one can identify most elements, especially the heavier ones such as cadmium, lead, mercury, zinc, selenium and manganese. This neutron activation analysis technique was a laboratory curiosity until after World War II, when radioactive neutron-emitting isotopes began being produced in quantity by nuclear reactors and certain accelerators. And it has come of age at a time when oceanographers and marine geologists need a convenient means of rapidly and accurately analyzing the superficial layers of the sea bottom. Traditionally, such analysis has been done by lowering scoops or corers from surface vessels, and often the number of samples has been so great as to require months to analyze the samples. Sometimes the data were ambiguous because of uncertainties of horizontal or vertical location of the sample.

Neutron illumination techniques show real promise here. The need for virtual real-time surveys is increasing with coastal heavy metals pollution and the increasing shortage and rising cost of such critical



Author Kurt Stehling (left), Dr. Peter Kotzer, and Ms. G. Wentz prepare photo emulsion detectors used in cosmic ray studies in Hydrolab, 50 feet below the surface of the ocean off Freeport, Bahamas. At right, a resultant "star-burst" detected on an underwater emulsion plate, showing "muon" interaction with a nucleus.





At the surface during NOAA's Marine Ecosystems Analysis (MESA) summer activation experiment is a barge holding support units and the "Beaver" submersible. Details of "Beaver's" manipulators holding an activation capsule are shown above right. Above left, Deepstar 2000 nears a neutron source package with a nuclear detector.

metals as manganese, cobalt, and copper. Most of these useful minerals and metal pollutants tend to congregate within the top 10 centimeters or so of the sea floor, which is, coincidentally, about as far as the neutrons can penetrate in aqueous mud. They can be generated by a machine source, but at present Californium 252, a synthetic Atomic Energy Commission-produced neutron-emitting radioactive element, is used to produce low or medium energy neutrons.

An even more sensitive activation technique for underwater use has been developed by the Atomic Energy Commission and Battelle Memorial Institute. Battelle scientists have adapted for marine use a process called X-ray fluorescence for scanning the first millimeter or two of the sea bottom from a submersible. Several heavier metals, not easily seen with the neutron-gamma ray method, are detectable with the X-rays. These can be produced by a compact X-ray generator, or by a radioactive X-ray emitter, cadmium (Cd 109) source. The X-ray method uses the fluorescence excited within an element's outer atomic (not nuclear) structure by the X-rays, a procedure something like illuminating a substance with ultraviolet light to make it glow. While sensitive, the X-fluorescence method permits only a penetration of about one or two millimeters of solid material.

Both techniques have a proven history of analytical applications in the laboratory and, in the last few years, in the field. German marine scientists and geologists have X-ray analyzed scooped-up ocean bottom samples for minerals. Dr. J. Noakes of the University of Georgia, with NOAA Sea Grant assistance and with cooperation from a pioneer in neutron activation, Dr. F. Senftle, of the Interior Department's Geological Survey, has adapted prototype neutron activation apparatus to submersible-mounted applications. Commercial off-shore sea bottom exploration companies have also applied the technique.

The first mission which applied X-ray and neutron activation to sea-bottom analyses from a submersible was conducted by NOAA's Manned Undersea Science and Technology office in a multi-agency activity in the New York Bight.[3] The Atomic Energy Commission was a major participant, with the U.S. Geological Survey and National Aeronautics and Space Administration providing expert support. New York State personnel, the Environmental Protection Agency and National Science Foundation observed the tests which, if successful, may signal an accelerating and widespread

application of underwater activation analysis for radioactive detritus and heavy metal pollutants which may affect or contaminate filter feeders like oysters. The tempo of surveys for commercial mineral assessments, and the detection of natural or man-caused oil seeps may also pick up, if the Geological Survey can adapt certain nuclear activation processes.

The New York Bight mission also included passive detection of radioactive bottom substances which may be deposited from land-based nuclear installations. The passive detection system, using geiger counters or solid state crystals, such as silicon, can detect naturally occurring radioactive minerals such as thorium or uranium, as well as radioactive tracer substances deliberately implanted into moving bottom sediments to trace their course and fate. Such tracer techniques have a long history of successful application and have been used by NOAA, the Army Corps of Engineers, and others, for marine gravel and sand tracer experiments. Biological specimens such as fish and crustaceans can also be tagged this way, by injecting or implanting microgram quantities of a radioactive substance into the organism and then noting its movements and relocations with suitable detectors.

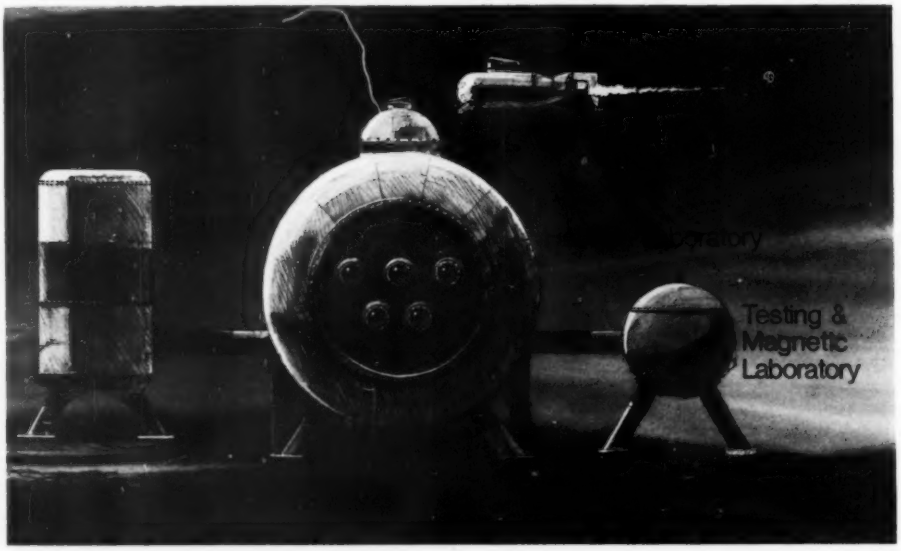
While NOAA and other investigators monitor and pursue trace amounts of short-lived radioactive elements along the ocean floor, others are looking at the ocean as a physics laboratory in which to learn more about two extremes in nature—the universe, and the sub-atomic particles which are not quite mass and not quite energy.

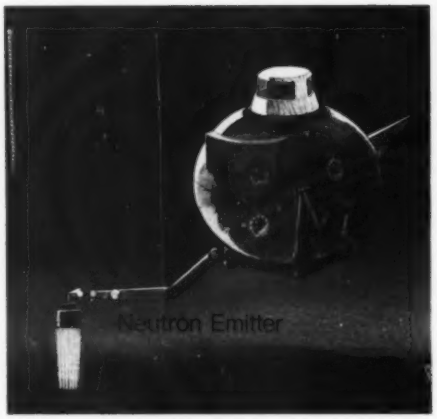
The sources of the undersea laboratory specimens are the great solar, and possibly galactic, generators of cosmic radiation in which the earth is always bathed. Most of these cosmic particles from space are deflected by the earth's magnetic field. They are transformed by interactions with atoms and molecules of upper atmospheric gases. Most of the cosmic survivors or progeny of the primary cosmic rays [2] belong to the meson family of K-mesons, p-mesons and M-mesons (called Kaons, pions, and muons [3]). And there is the neutrino, an apparent by-product of cosmic ray collisions, [4] that has no rest mass, is chargeless, and an important key to further understanding of interaction processes at the interatomic and galactic extremes of size. High-energy physicists are interested in taking this investigation into the ocean, to see what the cosmic bombardment does to marine organisms, and to use the peculiar insulating or filtering properties of sea water to improve their view of the particles themselves. Other phenomena such as galactic gravity waves may also be detectable at great ocean depths.

Professor R. A. Millikan, the American cosmic ray pioneer, did underwater cosmic ray experiments in Muir Lake, California in 1925 and 1926. He used electroscopes (which do not reveal the nature of the particles) to measure total ionizing flux, and proved that cosmic ray particles penetrate water. In fact, we now know that some particles probably can penetrate thousands of feet into the deep ocean, where they are comparatively more detectable than they are at the nuclearly noisy surface of the earth.

In early 1972, a very modest cosmic ray research activity was started under the sponsorship of the Manned Undersea Science and Technology Program. We canvassed some of the physics community, such as the Naval Research Laboratory's cosmic ray group headed by Dr. M. Shapiro, and got agreement that the ocean water interposes an isotropic (constant density) medium between an experimenter who wishes to study cosmic ray events and the source of cosmic nuclei and sub-nuclei, including mesons, neutrinos, and protons.

Experimenters have gone down into mines, using the earth's rocks and soil as a shield; however, the variations in composition and density of the earth's crustal layers introduce ambiguous filtering functions, leading to anomalies in muon and neutrino detection. Salt or fresh water, on the other hand, acts as a predictable and effective filter. In mid-1972, after some preliminary conversations with Drs. J. Lord and Peter Kotzer of the University of Washington, a cosmic ray experiment using stacked photo-emulsion detectors was proposed.





Above, an artist's conception of a multipurpose undersea habitat-laboratory installed on the ocean floor 20,000 feet below the surface. Connected by tubular crawlways, the facility includes a cosmic ray-neutrino laboratory and a gravity wave and siesmic/magnetic station. The two drawings immediately above show a Beaver-type submersible extending first one "arm" and then the other during neutron activation operations.

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[1] *Code-named "IGUANA" (Intra-Governmental Undersea Atomic & Neutron Analysis) Joseph Vadus, NOAA Project Manager.*

[2] *Mostly energetic protons, some helium nuclei ("alpha" particles) and a few heavier nuclei.*

[3] *The muon, first called mu-meson, is a maverick particle, not quite like a meson, and more like an electron.*

[4] *Neutrinos which can penetrate the entire earth without slowing down may also be coming from the sun, the galaxy or even from extra-galactic sources.*

The University of Washington group had previously tried to lower emulsion sandwiches in steel cassettes to the floor of Puget Sound. However, the plates had to be coated *above* the water, which resulted in fogging by the many and ever-present stray nuclear particles at the earth's surface. The emulsion is normally kept in a bottle and is still darkened, but *uniformly*, whereas it is spattered with myriads of obscuring trails and tracks if thinly coated on a plate at the earth's surface.

Taking advantage of Manned Undersea Science and Technology suggestions and background, Drs. Lord and Lotzer were able to add a very important innovation to cosmic ray detection: they planned to mount the emulsions *under* the water, in this case in the Perry Hydrolab off Freeport, Bahamas, which had support from the Manned Undersea Science and Technology Office.

The 50 feet of sea water was expected to act as a reasonably effective filter during the sensitizing of the emulsion stacks, which resemble a multi-deck sandwich. On February 8, 1973, Dr. Kotzer, Ms. G. Wentz, research assistant, and I, working in the Hydrolab with Robert Wicklund, manager of the Hydrolab, sensitized, coated, and packaged two emulsion sandwiches in waterproof cassettes, one placed within the Lab as a reference and the other at 100 feet. The Hydrolab was darkened with black cloth and a red photo light was used for illumination.

The reference emulsion was developed—still in the Lab—in April, and the 100-foot cassette was retrieved in early May and also developed. Then, at the University of Washington, the muon tracks within the emulsions were examined by microscope for evidences of muon-muon collision and other interactions. Several interesting collision interactions were observed.

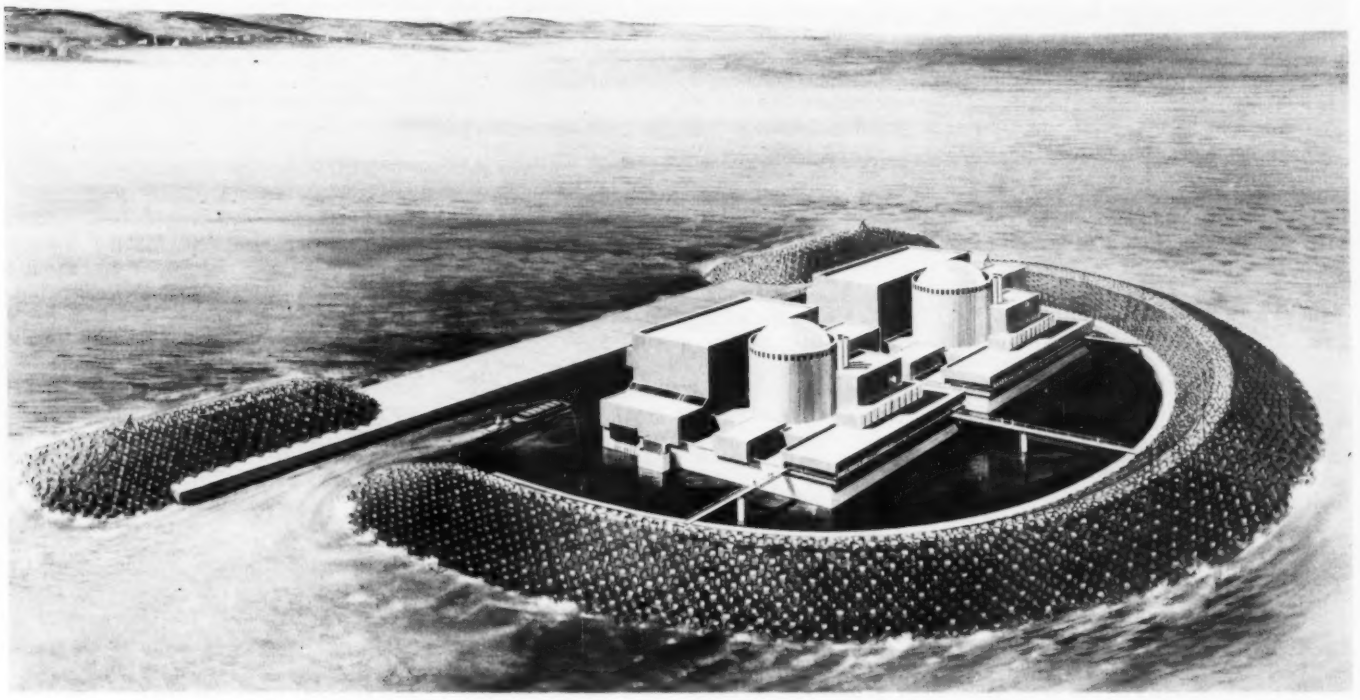
Because of previous coating problems, one set of emulsions was unusable and another set was then sensitized in May and coated by the by-now trained Bob Wicklund and Ms. Wentz. That package was placed at 150 feet depth, for retrieval in late August 1973. In March 1974, two more packages were implaced, one at 200 feet and one at 1,000 feet.

Neutrinos being essentially massless and chargeless sub-nuclear particles are most elusive and can only be readily detected by their complicated interaction with chlorine nuclei in large (10,000 gallons or more) tanks full of perchlorethylene or similar liquids. And neutrino researchers need to put these tanks into deep mines or deep water for these investigations. The ephemeral neutrino, whether from the sun or produced by cosmic ray muon interactions or collisions, is a poorly understood but undoubtedly important sub-nuclear particle whose fuller understanding might also help in fusion and other nuclear research. But neutrino research is an expensive proposition. So is the undersea study of gravity waves.

Dr. J. Weber of the University of Maryland's Physics Department is interested in studying the occurrence, magnitude and frequency of these waves, one of the most subtle and controversial manifestations of general relativistic mechanics. The deep ocean floor would provide a quiet location for a gravity wave detector of the sort that has been placed on the moon.

Several experimental schemes have been advanced, most of them using submersibles or deep-diving personnel transfer bells to emplace muon photographic-emulsion plates, neutrino tanks, and gravity wave detectors (this last senses the ringing of the earth under the influence of incoming gravity waves) in water a thousand feet deep or more. The plates would be retrieved at selected intervals, and the neutrino and gravity wave devices would report acoustically in real time to surface systems. But such work requires national and international backing before the search for new knowledge of cosmic processes can really begin.

Meanwhile, scientists in NOAA, AEC, industry and elsewhere continue to develop the sea as a nuclear reactor site, radiochemical workshop, and high-energy physics laboratory. Clearly the day is coming when the concept of the "atom in the ocean" will be identified as an innovative use of the marine environment for the benefit of ecology, and basic science, and for finding the resources to reduce our deficits in minerals, fuels and power.



The surrounding ocean would provide a natural coolant for the operation of this proposed floating nuclear reactor complex. The energy-absorbing breakwater facing the open ocean would provide a measure of protection from heavy seas. NOAA and other organizations are concerned with the impact such activities might have on ocean ecology.

The World Weather Building

Forecasting hub of the nation

BY EDWIN P. WEIGEL

When NOAA's new World Weather Building was dedicated last October 22, Administrator Robert M. White told an auditorium filled with guests that this was a moment of great satisfaction, the culmination of years of dreams and planning.

The new building, an ultramodern eight-story structure on the southeast outskirts of the nation's capital, draws together in one compact unit a number of NOAA's most important weather-observing and forecasting functions. It concentrates in one place an array of talent and instruments of unparalleled sophistication for the processing of weather data.

Among new occupants at 5200 Old Auth Road, Camp Springs, Md., are the National Weather Service's National Meteorological Center and the Washington, D.C., Forecast Office, and the National Environmental Satellite Service's elaborate new facility for processing photos from an improved series of geostationary weather satellites now coming into use.

With tenants such as these, the building is thus the operating nerve center for weather information for all of the United States and much of the rest of the world as well.

The National Meteorological Center projects weather trends on a global and national basis as guidance for regional and local forecasters in preparing more-detailed weather predictions for their areas. All of the Center's employees except those in computer communications are assigned to the new building from previous quarters at Federal Office Building 4, Suitland, Md. NMC's giant computers are too large to be moved. Their output will be transmitted two miles electronically to the World Weather Building with no loss in efficiency.

The new quarters assigned to some 260 employees of the National Meteorological Center are on the second, third, fourth and sixth floors of the World Weather Building. NMC shares the third floor with the Washington Weather Service Forecast Office and the sixth with the National Environmental Satellite Service (NESS). NESS occupies all of the fifth and seventh floors, as well. Other NOAA occupants include members of the Weather Service's Spaceflight Meteorology Group.

Only the first and eighth floors of the rented building are occupied by other than NOAA tenants.

Showpiece of the World Weather Building is the new NESS satellite data-processing facility, and much of the architecture was designed to accommodate this unit. Here, visitors see a dazzling array of new equipment for automatically processing and distributing photographs made by new, operational geostationary satellites. The first of these was launched last May and is now beaming back a steady stream of full-disk photos of the Earth from a spot 22,300 miles (35,680 kilometers) high over equatorial Latin America. The photos arrive every 30 minutes, night and day, and are sectorized (divided into smaller geographical areas) to provide detailed information on cloud cover, temperatures, and high-level winds for a large number of localities in North and South America.

The satellite now providing such photographs was funded by the National Aeronautics and Space Administration and is designated SMS–1 (for Synchronous Meteorological Satellite No. 1). A second such NASA satellite, SMS–2, will be stationed over the Pacific. Later satellites in the series, funded by NOAA, will be called GOES, for Geostationary Operational Environmental Satellite. The first GOES satellite is now being built; there are contracts for two more.

Among the advantages these new satellites have over earlier geostationary satellites such as NASA's ATS–1 and ATS–3 are the ability to provide photographs of unprecedented resolution in daytime (as fine as one-half mile) and to provide photographs at night by infrared or heat-sensitive photography.

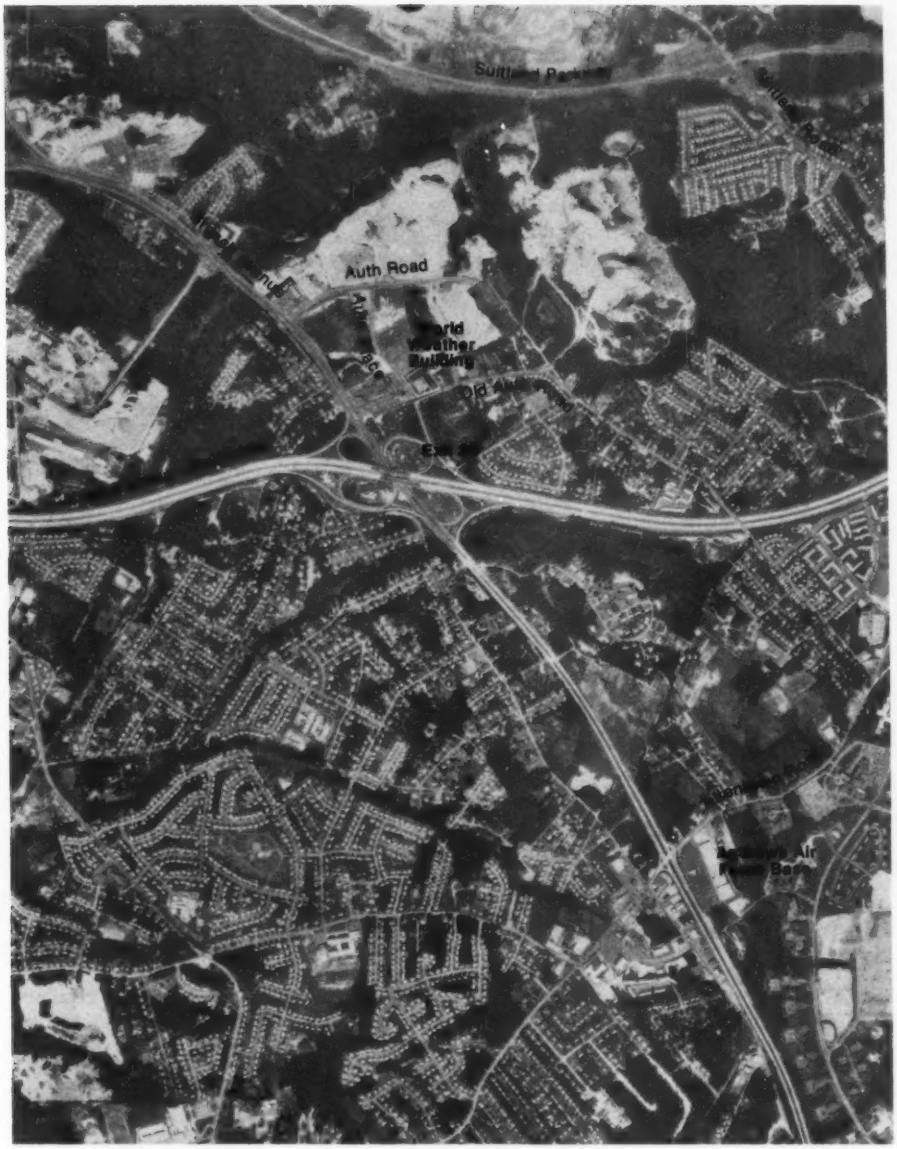
A globe-girdling system of five such satellites is planned, according to the World Meteorological Organization. Three similar geostationary satellites are to be placed at selected spots over the Equator by Europe, Japan and the Soviet Union. These, coupled with the United States' satellites, will provide, for the first time, day-and-night photographs of the entire Earth except extreme Polar regions on a nearly continuous basis. The plan calls for the European Space Research Organization (ESRO) to position one at the Greenwich Meridian or zero degrees longitude; for Japan to place one at about 140 degrees east, looking down on New Guinea, and the USSR one about 60 degrees east, over the Indian Ocean. Photos and data are to be shared.

The new World Weather Building located at Camp Springs, Md. houses several other NOAA facilities, making it the nerve center for weather data for the entire United States and much of the rest of the world. The map (right) pinpoints the location of the center in relation to other Weather Service units and the buildings in which they are housed.

Thus the GOES Central Data Distribution System at the World Weather Building is a pioneer facility in a weather-observation program aimed at benefitting all mankind. It was appropriate that guests at the dedication ceremonies last October included Mr. M. F. Taha, head of the Egyptian meteorological service and president of the World Meteorological Organization, and Dr. D. A. Davies, Secretary-General of the WMO.

Concluding highlight of the ceremony was a conducted tour of the new building led and narrated by W. John Hussey, head of the NESS Field Services Division. What follows is a simplified and condensed description of what the guests saw and heard on that tour.

Before starting out, Hussey explained that the World Weather Building is the primary place where operational data from new geostationary satellites such as SMS–1 is being processed.



"To arrive at this building," said Hussey, "data from the satellite is first picked up by a 60-foot dish antenna at the NOAA/NESS Command and Data Acquisition Station at Wallops Island, Virginia, on the Atlantic coast.

"There, the data for the future picture is 'stretched' with special equipment to make it receivable by a smaller antenna. Then, it is transmitted back up to the satellite from Wallops and down again to a 24-foot antenna at Suitland, Md., about two miles from here.

"From Suitland, the picture data is transmitted by microwave to this building."

Hussey then led guests to a large room on the fifth floor filled with electronic equipment. At the sides were numerous cabinet-sized units with transparent plastic faces revealing reels of magnetic tape. Near the room's center was a console with eight TV-type displays flanking a typewriterlike keyboard and a panel of buttons. It was manned by engrossed young men poring over complicated tables.

"This is the Central Data Distribution facility of NESS," he said. "It is the heart of our system, and contains the sectorizers," pointing at one of the large cabinets. "There are 18 of these and each one contains a minicomputer, some tape drives, and a TV-type display to show what's in the computer memory and what's happening to that information.

"What a sectorizer does is to take a full-disk photo of the Earth and sectorize it; that is, extract a small section, for transmission to a particular place. We do this because we cannot transmit a full-disk high-resolution photo over a three-kiloHertz telephone line.

"We then transmit each sector to a particular user. For example, a sector showing northeastern U.S. goes to Boston and New York; another sector goes to Kansas City, another to San Francisco.

"By this means we transmit data of interest to local users without overloading our communications system by sending the whole disk of a high-resolution photo made by visible light. Field stations can get a full-disk infrared picture that has less resolution, if they want, but we don't display the full-disk high-resolution daylight photo anywhere in our system."

Hussey then moved to the console at the center: "This is our central control console. It controls the 18 sectorizers and is tied in with two computers and a computer-controlled crossbar switch which routes sectorized photos to places such as Miami, Kansas City, San Francisco and eventually Honolulu. All of this is programmed into the computer so that at a certain time of day certain sectors go to specific cities. The system is operating 24 hours a day, taking photographs made every 30 minutes and transmitting them to various users." He added:

"There's always a man sitting at this console. He can override the computer anytime. If, for example, there's a severe thunderstorm or tornado in a certain area, he can interrupt and focus on that. So you can see this is an extremely important place. All the communications lines for the GOES data-distribution system terminate here."

Hussey then moved to an adjacent room filled with numerous smaller cabinets the size of automatic dishwashers. "These are Muirhead photographic recorders," he said. "They take the data that comes to them from the sectorizers in electronic form and turn it into photographic negatives. This is done by means of a lunchbox-sized cassette in which a piece of 11 ×11 inch film is wrapped around a drum and inserted in a recorder.

"After the film is exposed it is put through a light trap in the wall to a photographic darkroom where it is developed."

We moved into the darkroom.

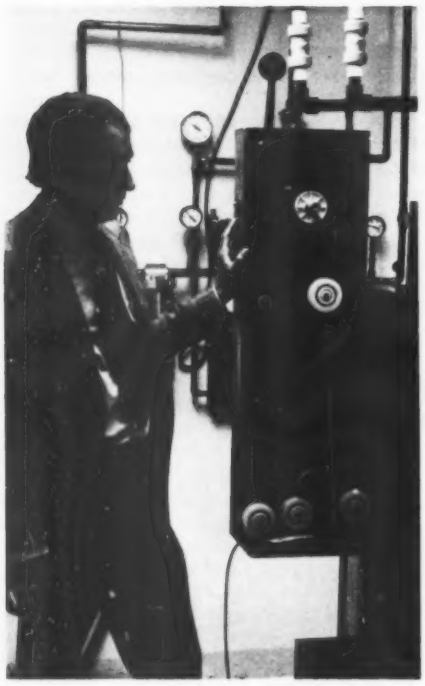
"After the film comes through the wall opening into our darkroom, it is removed from the cassette and processed with various chemicals automatically kept at the proper temperature and concentration—a very critical need. All of these chemicals come from a central source and are plumbed in to the various darkrooms in the building. Just about everything is automatic; all we do is keep an eye on the gages. Chemicals are mixed and kept at the proper temperature automatically; film is processed automatically. We're also ecology-minded. We recycle the silver from the chemical solution. That canister over there with the plastic tubing has a catalyst in it that extracts silver. Every so often we ship a canister away and the Government gets dollars back."

Then to another room adjacent:

"The negatives come here after processing. They are given quality-control checks to make sure they're uniform, logged in and checked on a densitometer. Then they go over to a gridding area, where a plastic sheet with latitudes and longitudes and outlines of land masses is placed on top of them. Then they go to another darkroom."

We followed:

"This is where we make the contact prints. These automatic printers will make as many as 20 to 30 prints of the same negative at a speed of 30 feet per minute. The prints are developed using the same type of auto-



Photos: Edwin Weigel

W. John Hussey (above) head of the NESS Field Services Division, explains the functions of a motion picture loop processor. At top right is the "sectorizer room" which extracts small sections of full disk photos of the earth for certain cities. The central console is at right, and far right is the recorder room, where satellite negatives are produced.

matic equipment as for the negatives."

We went to still another darkroom used for making 24-inch enlargements, and thence to a room containing equipment for producing 16-millimeter movie film.

"This is where we make our movie loops," said Hussey, "the time-lapse movies of clouds in motion. These are simply a series of half-hourly satellite photos that have been transferred to 16-millimeter movie film. The device that makes them is driven by another minicomputer. It can be programmed to turn out four or five duplicate movie loops at a time. When a movie loop is run through a projector you get a motion picture of clouds as they coil and swirl. By tracing individual clouds, you can determine wind direction and speed. We make loops that cover 3-, 6- and 12-hour periods.

Thence to another room, dominated by a large TV-type screen with an enlarged satellite photo displayed. "This is our Man Machine Interactive Processing System—MMIPS for short." Hussey then introduced another young meteorologist, Ron Gird, who picked up the narration.

"The MMIPS machine calculates cloud temperatures for the meteorologist using an infrared picture from a GOES-type satellite.

"For example, I will put an infrared picture—a full-disk GOES-type picture—on my screen and then locate an area where there is likely to be good cloud motion. Then, superimposing on the screen a movable white pointer called a target locator, I can select a point on the picture I want to examine more closely, and I will ask the MMIPS machine to extract the cloud temperature there.

"Next, I get a movie loop showing that cloud, and I track it over distance and time.

"Then I put all this information together. From the temperature of the cloud I can judge quite well its altitude—the colder the higher, generally. From the speed and direction of the cloud I then get the wind at that level.

"This is the same sort of information we get from instrumented balloons and from aircraft, and it's treated the same way—that is, transmitted to the National Meteorological Center and placed in the computer to show large-scale atmospheric circulation. While we can by no means supplant the balloon-borne radiosondes, we can provide data from places where you can't get it by usual means—what we call data-sparse areas, such as remote places over the Pacific Ocean."

Before we left the fifth floor, Hussey stopped by two large red-and-white metal cylinders:

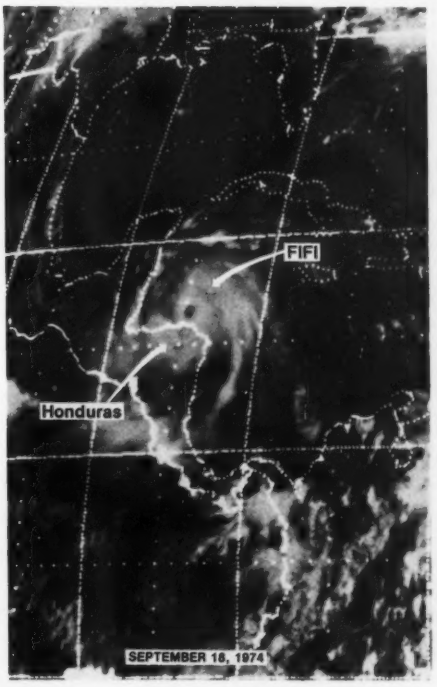
"I'm proud of these. They're part of the special fire-suppression system in our primary electronics area—completely separate from the rest of the building. It's called a Halon system, named for a patented gas made by the Du Pont Company. I don't know the composition of the gas because it's an industrial secret, but I can tell you what it does.

"It will automatically put out a fire without damaging equipment the way a water-sprinkling system does, and it will do this without people having to leave the room after the gas has been released. Unlike carbon dioxide, you can breathe this gas and it won't hurt you.

"Each room on this floor is independently supplied. In case of a fire the air-conditioning system would shut down automatically and the gas would be released. Within six seconds there would be a seven per cent concentration of Halon in the room. It reacts right at the flame front, removing oxygen to put out the fire.

"We put such a system in here because we can't afford to have this area shut down for any length of time. Halon systems are also used in the Pentagon, in banks, and by a major food chain in its central computer area—places where any loss of data in the computer system would be very, very bad. It's not cheap, but it's worth it.

"Another thing—we're on a separate air-conditioning system from the rest of the



Motion picture loop of storm clouds over Atlantic are studied by Forecaster Eugene Hoover and Meteorologist in Charge Jerrold A. La Rue at new Washington, D.C. Forecast Office. Map on right shows Hurricane Fifi at most lethal stage moving westward from the coast of Honduras September 18, 1974. Satellite photo 23,000 miles over Equator.

building. And we're on a raised floor. You can feel the air coming up. We have our own cooling tower on the roof, our own condensers, everything required for an independent operation.

"We also have our own power generators outside, for emergency power. These can provide power to run our air-conditioning system, lights, and of course our equipment. It's a diesel system, supplied by a 5,000-gallon tank of fuel, underground.

"We don't wait for a power failure to use it. If there are thunderstorms within 25 miles of this area we go to emergency power so we're protected. Even a momentary loss of power will mess up the minicomputers in our sectorizers—affecting the software, the computer programs. We can't afford that."

Next we went down two floors to the third floor.

"Here we have the Washington, D.C., Satellite Field Services Station (SFSS). We have similar stations in Miami at the National Hurricane Center, in Kansas City at the National Severe Storms Forecast Center, in San Francisco at the Weather Service Forecast Office, and we have one planned for the Honolulu Forecast Office.

"What you see here is material that comes to field units from the NESS Central Data Distribution facility on the fifth floor. It's distributed to the field by land line. Each of the Satellite Field Services Stations receives inputs from the sectorizers. From the SFSS, the data goes into a machine that distributes it to various other stations tied in to that particular station. For example, here in the Washington SFSS right now, we have Detroit, Boston, New York and Atlanta Forecast Offices tied in, and receiving data. In addition, Penn State University is tied in, at its expense, and Weather Service headquarters at Gramax Building has a drop.

"Those are the current users. Later on, there'll be a total of 14 Forecast Offices tied in, plus possibly other users.

"We have two meteorologists on duty here, around the clock, analyzing satellite data and integrating it with conventional Weather Service data. Right next door is the Washington Weather Service Forecast Office, which prepares forecasts for D.C., Delaware, Maryland and Virginia. So it's easy for the satellite meteorologists to work with them. To get data to the more-distant Forecast Offices that are tied in, we send satellite photos by land line and they are received on a device that makes a positive print without an intermediary negative.

"It's like a wirephoto system that the news media use. We use it because the other Forecast Offices don't have elaborate photo labs like we have upstairs and in our Satellite Field Services Stations. It gives them satellite service at relatively low cost."

Hussey then said this concluded his portion of the tour and summed up by saying it has been a most exciting and rewarding period for him personally. "We have put this whole system together in a year and a half, introducing a major change in our satellite data-distribution system. When I got the job of chief of the NESS Field Services Division, I began as a one-man division. Now the Division has 60 civil servants and about 100 contractor personnel working for it."

The next step on the tour was the third-floor offices of the Weather Service Forecast Office for Washington, D.C. and vicinity. Meteorologist in Charge Jerrold A. La Rue said the new quarters have been responsible for a tremendous boost in morale on his staff.

"We didn't acquire a lot of exotic new equipment by coming here; nor are we changing our mode of operations in any significant way. But there is a big difference in the way people feel about this place. From quarters that were noisy, crowded, dingy and drab, we have been transplanted to a setting that is quiet, spacious, clean and attractive. Before, our people were not proud of where they worked. Now they are. Just about everybody has brought his family out to see this place. They're happy now. And that's important."

Surprises awaited Project FAMOUS scientists, as submersibles gave them

Man's First Look at the Mid-Ocean Ridge

BY SUSAN H. ANDERSON*

The greatest natural feature on the surface of the earth—the Mid-Ocean Ridge—lies beneath the world's oceans, and was not discovered until early in this century. Since then numerous expeditions have explored it from the surface, using conventional oceanographic tools and, more recently, modern electronic sensors.

In 1972 an international research project was created to find out more about the axis of this vast mountain range. What could it tell us about the origins of the earth's crust and the motion of giant lithospheric plates across the earth's surface? Could we learn more about the geology of continents, especially the formation of metallic ores, from the hydrothermal processes at the rift axis? In what way are the processes occurring at the axis important to a broader understanding of the evolution of continents as we know them today?

A series of well-coordinated oceanographic expeditions from several nations was climaxed by submersible exploration of the rift valley. For the first time man was able to look at parts of the ridge, observe the valleys, bring back from the depths specimens that he had chosen to examine, and compare what he saw with what had been predicted. This project was called Project FAMOUS—for French-American Mid-Ocean Undersea Study—and it held much excitement and some scientific surprises for the participants.

"We're coming up to a very sharp crest here, many broken blocks right up to the crest, very large fractured pillows. And now we see a very large bulbous pillow off to the left . . . very much older lava and broken . . . Just went over a deep ravine and coming onto another steep scarp, but still much more sediment covered. Looks like a much older slope . . . There's a lot more coral, a lot more sediment dusting, really quite a pronounced change in the character of the slope."

Dr. Wilfred B. Bryan of Woods Hole Oceanographic Institution, one of the American scientist-divers of Project FAMOUS, was continuously taping his observations as the small deep-diving submersible ALVIN made its way along the floor of the great central valley of the Mid-Atlantic Ridge. What he was seeing and describing, and what the cameras on ALVIN were recording, was a traverse that crossed from an area of very new seafloor to an area of much older volcanic terrain, where increased tectonic activity was evident. During its dives the submersible made several similar crossings, and the scientists aboard noted the sharp, well-marked contrast between the new and the old topography.

Photo: Robert Ballard

Photo: Woods Hole Oceanographic Institution

Pilot John Donnelly, flanked by scientists Robert Ballard and James Moore, caught by fisheye camera in cramped quarters of submersible ALVIN (top). At right, dike in west wall of rift valley, seen by ALVIN external camera. The submersible's sample tray, at bottom of photo, carries water samplers, sediment corers, and other equipment to obtain material for laboratory analysis.

**Susan H. Anderson is Administrative Coordinator for the U.S. portion of Project FAMOUS. This is contribution No. 3459 of the Woods Hole Oceanographic Institution.*

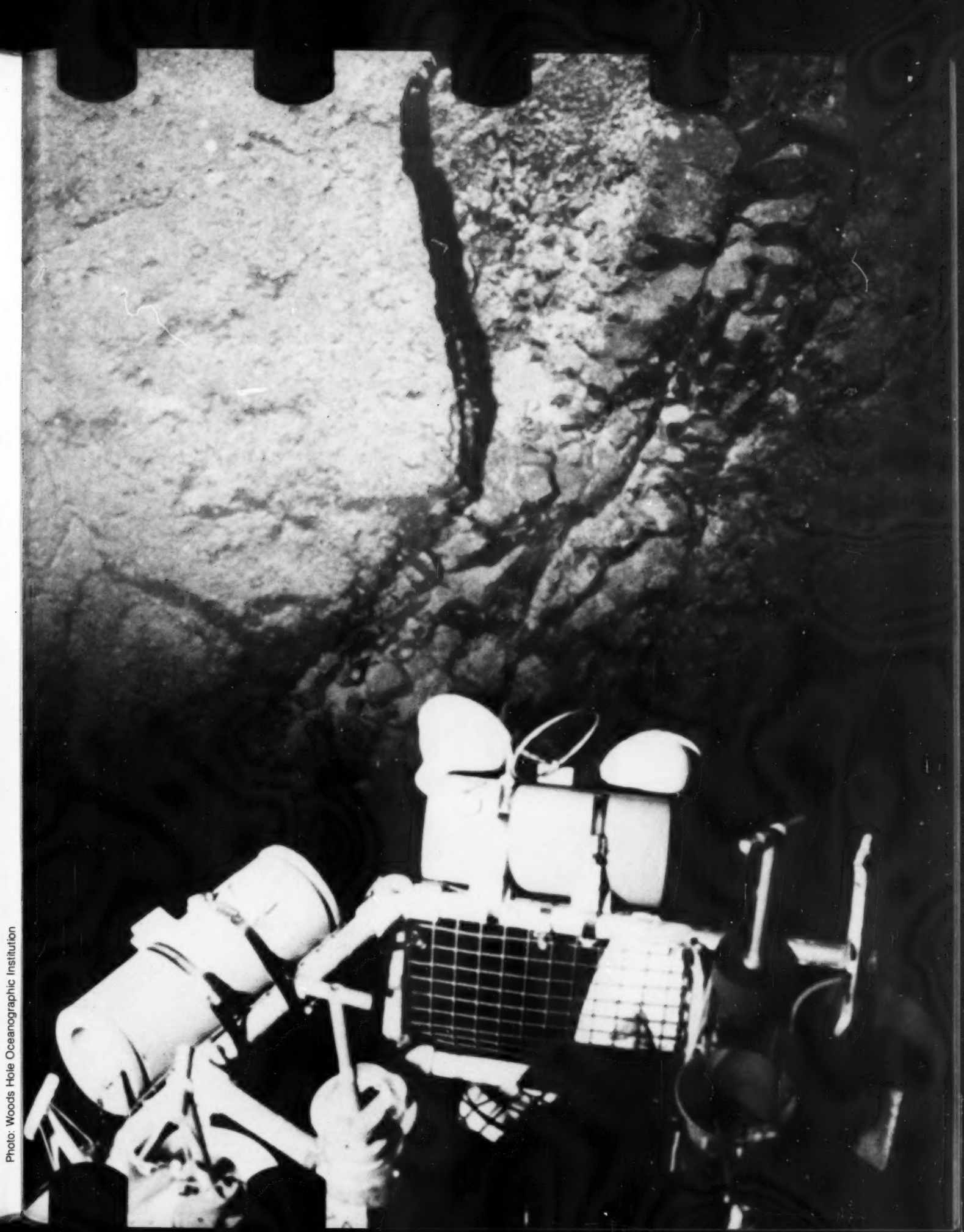


Photo: Woods Hole Oceanographic Institution

During the summer of 1974 the ALVIN and two French submersibles—the bathyscaphe ARCHIMEDE and the Cousteau-designed CYANA (formerly "Diving Saucer 3000")—provided the opportunity for man to view firsthand portions of the lithospheric plate boundary on the ocean floor. Forty-two dives in all were made by the three craft in the depths of the Mid-Atlantic Ridge rift valley and adjacent fracture zones at approximately 36°30′ N. At depths from 7,200 feet to 9,600 feet, the three submersibles carried scientists of the two nations for more than 50 kilometers through the rugged terrain created by both volcanic and tectonic processes.

In addition to Bryan, the American diving scientists were Dr. Robert D. Ballard of Woods Hole, Dr. George H. Keller of NOAA's Atlantic Oceanographic and Meteorological Laboratories, Dr. James G. Moore of the U.S. Geological Survey in Menlo Park, California, and Dr. Tjeerd van Andel of Oregon State University. Their work in ALVIN emphasized a study of the narrow inner rift valley floor in the vicinity of a feature that they named Mt. Pluto.

The view from ALVIN is, of course, very limited. "Somebody once compared mapping the seafloor by indirect methods from surface ships to mapping the earth by indirect methods from an airplane above the clouds," said NOAA's Dr. Keller. "Well, looking at the Mid-Ocean Ridge from ALVIN is like looking at the Rockies in a heavy fog—you can see the details, but you never get a panorama of the countryside. It's a great step forward from indirect observations, but you have to plan your traverses very carefully to get the most out of them."

The U.S. planning was accomplished jointly by Dr. James R. Heirtzler, U.S. Project Chief Scientist, and the scientific diving team.

By coupling what was already known with what they were seeing, they could carefully plan each new submersible traverse. As operations and analysis proceeded, they were able to develop an understanding of how the features they observed related to the overall "landscape"—and to the concepts of plate tectonics.

In 15 dives in the rift valley, ALVIN pilots Lawrence Shumaker, John Donnelly, Dudley Foster, and Valentine Wilson drove the submersible over a fantasyland of rock pinnacles, hollow tubes of lava, "haystacks," hollow "blister" or "eggshell" pillow lava, and sometimes gaping fissures. ALVIN went into fissures, traversed along ridges of the median highs and across structural depressions, and climbed the steep western wall of the valley to enable scientists to observe the geologic structures in detail.

Cumulatively, the observations made on the dives provide evidence that, although the zone where volcanism extrudes new material into the earth's crust is very narrow, it is not a simple line through the center of the valley. Instead, it is a complex series of fissures, downfaulted blocks or grabens, and volcanic features.

"Most surprising to some of us," said Dr. Heirtzler, "was the very clear evidence that lithospheric plates are being pulled apart—not pushed apart by volcanism. As seen from ALVIN's viewports, the features along that part of the ridge suggest that volcanic intrusion of new sea floor at the boundary is a consequence of seafloor spreading, not a cause of it. This is going to require some change in emphasis of our study."

The concept of mounting an intensive research program on one segment of the Mid-Ocean Ridge system was developed

Photo: CNEXO

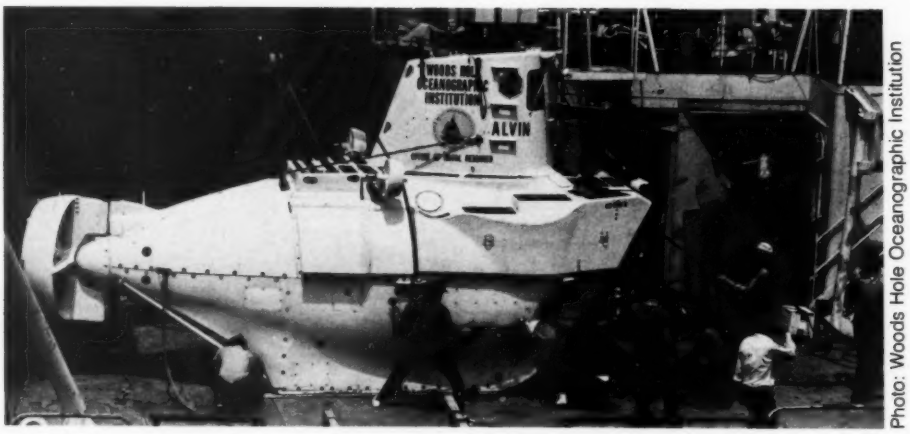
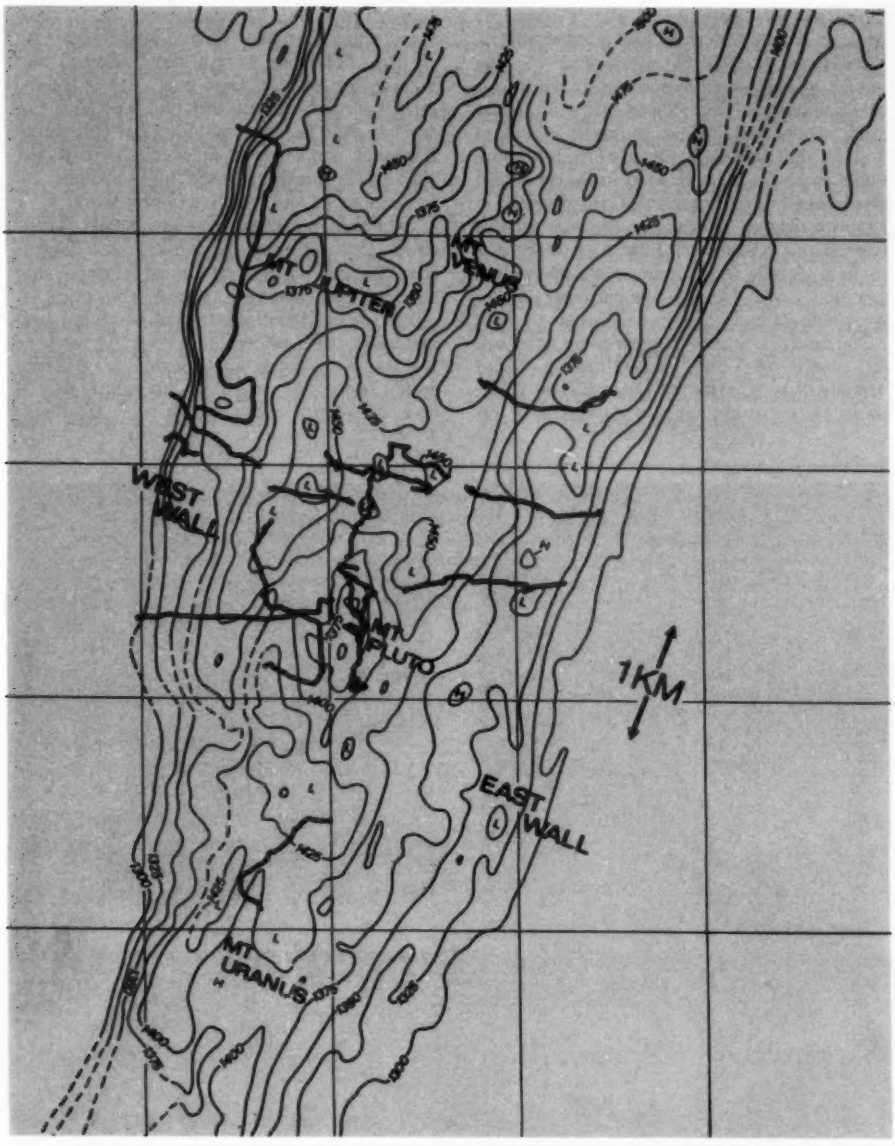


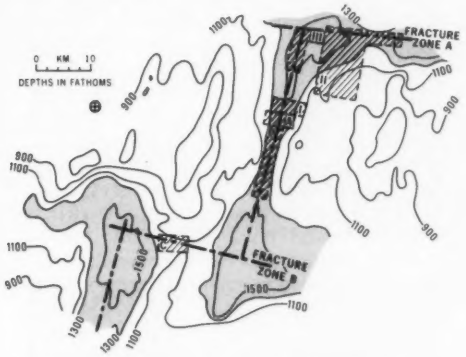
Photo: Woods Hole Oceanographic Institution

The three deep-submergence vehicles used in 1974 dives of Project FAMOUS. Above, CYANA, Cousteau-designed French craft formerly known as Diving Saucer. Above right, U.S. submersible ALVIN; below it, the French bathyscaphe ARCHIMEDE. ARCHIMEDE made seven reconnaissance dives on Mid-Ocean Ridge in 1973.

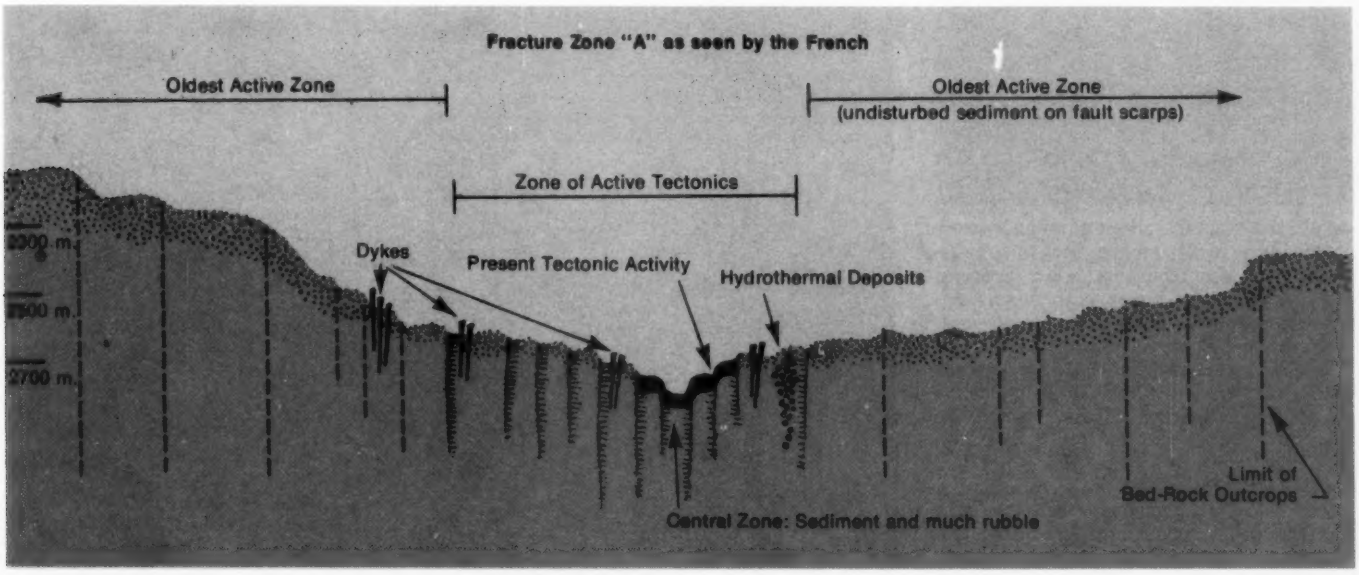
almost simultaneously through both the French-U.S. Bilateral Cooperative Program in Oceanography, headed in the U.S. by Dr. Robert M. White, Administrator of NOAA, and the International Decade for Ocean Exploration at the National Science Foundation. A workshop sponsored by NSF's office of the International Decade of Ocean Exploration and conducted by the Ocean Affairs Board of the National Academy of Sciences brought together, in January 1972, more than 40 scientists from six nations. All were interested in pursuing intensive research of mid-ocean ridges, and five of them—Heirtzler, Ballard, Keller, and Moore of the United States and Xavier Le Pichon of France—were later to be members of the FAMOUS expedition.

The workshop participants tried to identify what was known about the processes occurring on the mid-ocean ridges, what questions were still to be answered to gain better understanding of the significance of ridge systems, and what technology existed and could be used to answer some or all of those questions. Even before the report of the workshop was published, scientists who had been involved had begun to think about





French dives (Roman numerals, above) were on Fracture Zone A and main rift valley; ALVIN dives (capital letters) on Zone B and rift valley. Exact tracks of ALVIN in rift valley as recorded by computer, shown above left.



ways best to implement the recommendations of the report. Thus it was through multiple interests that Project FAMOUS was formulated.

The Mid-Ocean Ridge system makes its way from the Arctic Ocean through the North and South Atlantic, around the tip of Africa and up into the Indian Ocean. Here it splits, with one part extending into the Red Sea and the other running south of Australia and across the Pacific to the East Pacific Rise near the coast of Central America. The problem: how to choose a site for man's first direct look at this vast system, and how best to make the study once the site was chosen.

Because of the involvement of French and American scientists, a portion of the ridge in the Atlantic was an obvious choice. The site selected, 380 nautical miles southwest of Ponta Delgada in the Azores, was chosen because here predicted weather patterns suggested a period of nearly three months each summer when the sea would be calm enough for the launch and recovery of ALVIN, ARCHIMEDE, and CYANA. This location was also within a few days transit of an acceptable port for logistic support, Ponta Delgada.

"Once we had a site, we had to lay out the best method for studying it," said Dr. Heirtzler. "We started with broad surveys using the most up-to-date technology available, and followed up with increasingly detailed studies of the portion selected. The capstone was the series of direct observations from the submersibles."

In the late fall of 1971 the U.S. Navy had run extensive aeromagnetic surveys in the Atlantic which included intense coverage of a 20,000-square mile area around the selected operation site. This survey showed a symmetric magnetic anomaly pattern representative of a "typical" part of the mid-ocean ridge system.

Three cruises of the Naval Oceanographic Office and Naval Research Laboratories in the winter of 1972 and 1973 provided FAMOUS participants with increasingly detailed bathymetric charts of the area. The now published versions of these charts show some of the key areas with five fathom contours.

Meanwhile in the fall of 1972, participating research institutions in France and the U.S. began more conventional surface ship investigations. Already, participants had decided to concentrate on the two fracture zones and two rift valley segments between 37°N and 36°N. A total of 18 cruises went into the area to determine parameters of the rift valley and fracture zones through bottom photographs, rock sampling, heat flow measurements in the sediments, water temperature measurements, side scan sonar, microearthquake monitoring, and current measurements.

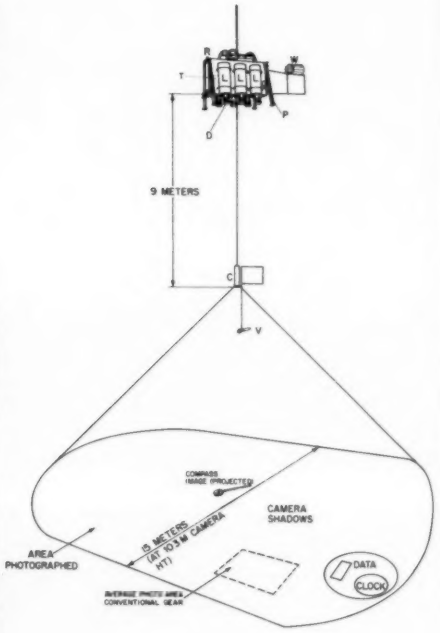
In the summer of 1973, ARCHIMEDE made seven preliminary dives in the rift valley on a central high, which the French named Mt. Venus, to reconnoiter the topography and the extent to which surface ship efforts had provided useful data on the scale of a submersible. The culmination of the project was the full scale operation during the summer of 1974, with three submersibles diving at the lithospheric plate boundary between North American and African plates.

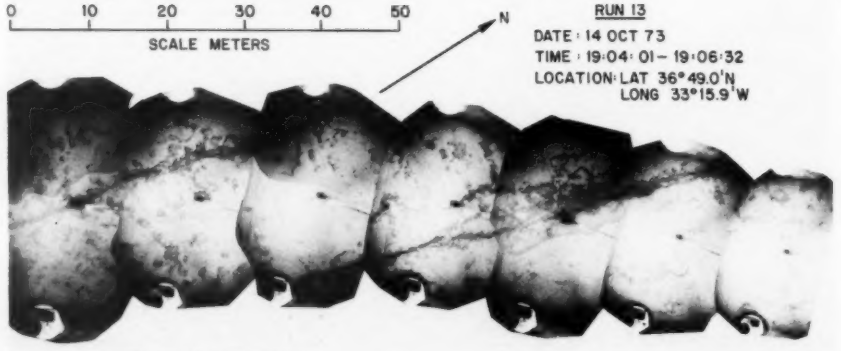
On June 4, 1974 ALVIN—after making several test dives in Woods Hole Harbor—was hoisted on the R/V KNORR with her trawl winch and lashed securely in place. Even at that late date there were still some details to be finished in tying in the scientific instruments with a recorder in ALVIN. A skeleton group from the ALVIN group boarded the KNORR on June 5 to work out the final details as KNORR, with ALVIN on deck and LULU (ALVIN's support vessel) in tow, made its way to Ponta Delgada.

On June 21, a full complement of scientists were on board KNORR in Ponta Delgada. LULU, with ALVIN back on deck, left in the morning for a deep test dive off San Miguel and KNORR passed her making way to the dive site to make preparations for ALVIN. Following several days delay in port waiting for an electronic part, LULU headed into the open ocean, and bad weather. For several days the seas pounded her catamaran pontoons and covered the decks with water. Finally the weather eased up. On June 29, LULU was on site, ready to begin work.

While ALVIN dove, KNORR usually stayed about 15 to 20 miles from the LULU. Scientists aboard KNORR continued surface ship surveys, maintaining a support laboratory for archiving rock samples, and studying and annotating dive photos. Most of the work of KNORR was concentrated in the two fracture zones north and south of the prime ALVIN dive area, with emphasis on rock sampling,

LIBEC Naval Research Laboratory deep-towed instrument package LIBEC (*LI*ght *BE*hind *C*amera) produced mosaic photomaps of area to be investigated by French and U.S. submersibles. Sketch shows how 8,000 joule electronic flash lamps (L) provided light directed by device (D) to outer edges of camera's field of view. Suspending camera well below light avoids intense backscatter. Rectangle in photo (left) represents conventional undersea photo area superimposed on LIBEC photo. At bottom, LIBEC photomap used in FAMOUS planning.





Photos: Naval Research Laboratory

Photo: Woods Hole Oceanographic Institution

photographic coverage, and temperature measurements. Work in Fracture Zone A to the north was carried out first to provide additional information to the French who would be diving there.

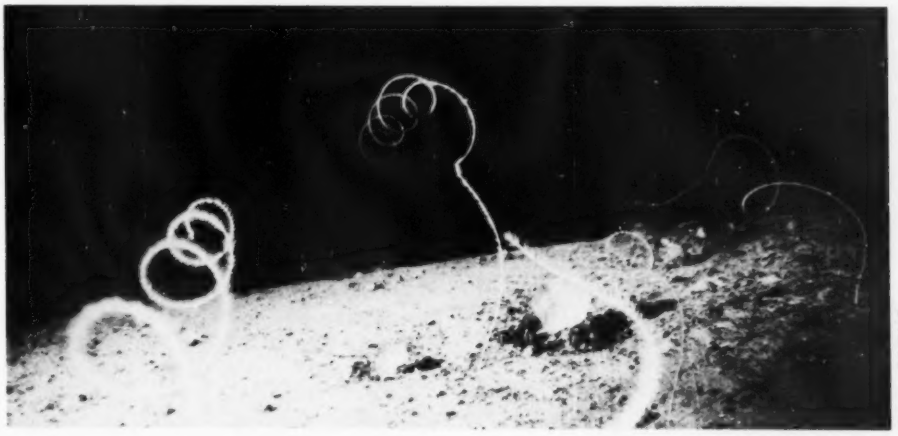
Although ARCHIMEDE and CYANA were delayed in starting their diving program, they were able to continue diving through the end of August, making a total of 27 dives in the northern part of the rift valley and in Fracture Zone A. There was one day on which both ARCHIMEDE and ALVIN were diving at the same time and were able to communicate under water. Because there is a 3-day turnaround between dives for the ARCHIMEDE and she made many of her dives at night, underwater communication between submersibles was a rare occurrence.

Inside ALVIN a Brush recorder continuously recorded the depth of ALVIN from the surface, height off the bottom, time, and heading. Several optional channels were used for sediment heat flow, water temperatures and magnetic measurements. A special sonar enabled the submersible occupants to "see" beyond the range of ALVIN's lights.

"The use of the sonar was invaluable in driving the sub through the extremely rough terrain," commented pilot Lawrence Shumaker. "With our sonar, we could detect objects 200 to 300 meters away, so that we had time to turn and avoid the more hazardous objects. Even small objects the size of a breadbox could be seen up to 100 meters from ALVIN. The special advantage of the sonar in FAMOUS was that it allowed us to see a map-like presentation of the 'landscape' so that the scientists could plan our exploration to maximize time on the bottom."

Both external and internal cameras were used to document all that was seen from the submersible, and each science diver made a voice recording of his observations. From these photographs and recorded impressions, the scientists are able to make geologic charts representing the intricacies that they observed on the rift valley floor.

The pilots could navigate ALVIN with great precision, thanks to three acoustic transponders placed on the bottom of the rift valley, all at approximately the same depth. Their positions were determined with great accuracy as a result of intense surface



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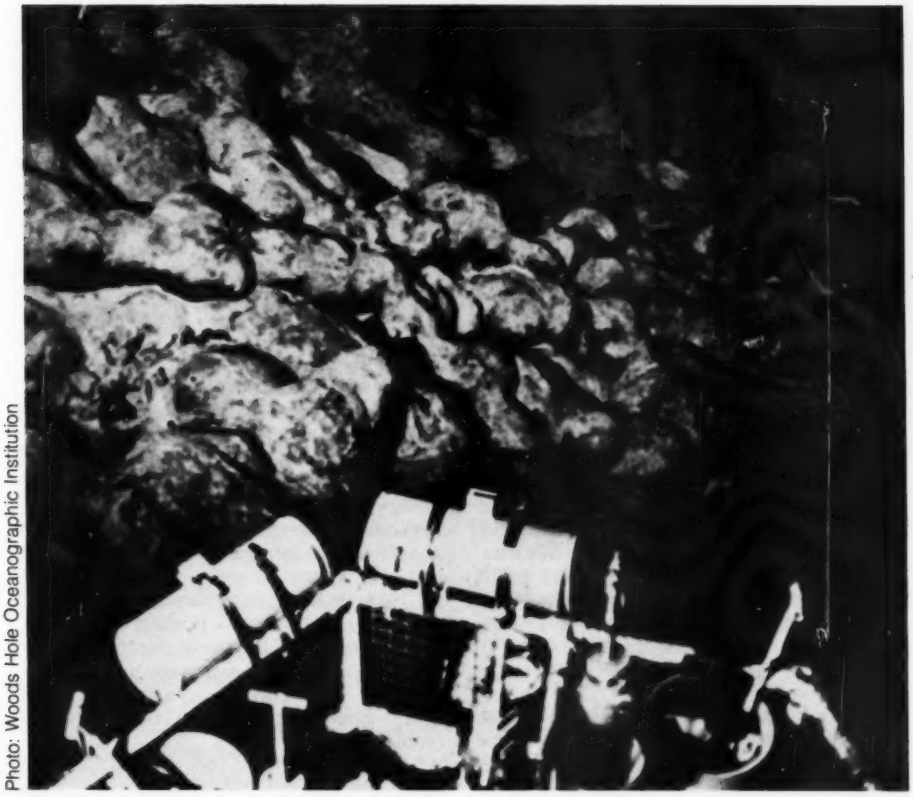


Photo: Woods Hole Oceanographic Institution

Strange and varied fantasyland was seen by FAMOUS scientists diving on Mid-Ocean Ridge. Top left, lava "trapdoor" extrusion, a broken piece of crust resting on project neck of lava. Bottom left, ribbons of smooth pahoe-hoe lava on the slope of a mound ("haystack") formed from point source extrusion. Top right, spiral organisms photographed by French. Bottom right, ALVIN mechanical arm sampling rock, with typical large grooved tubular lava extrusion beyond.

U.S.-French Cooperation in Oceanography Made FAMOUS Possible

Any international scientific effort represents the integration of numerous cooperative efforts by working scientists, by government officials, and by supporting groups of many kinds.

Project FAMOUS involved, on the U.S. side, the Woods Hole Oceanographic Institution as operating arm, with support by the National Science Foundation, the U.S. Navy, and NOAA. On the French side, the Centre National pour l'Exploitation des Oceans (CNEXO) and its laboratory, the Centre Oceanologique de Bretagne, carried out much of the work jointly with the French Navy.

From an intergovernmental viewpoint, Project FAMOUS had its origins in a 1970 agreement by France and the United States to initiate a joint program in cooperative ocean programs. At the outset the Mid-Atlantic Ridge was one of the topics of chief interest, and the earliest U.S. scientific leaders designated for the proposed project were Dr. James B. Heirtzler of Woods Hole Oceanographic Institution and Dr. George H. Keller of NOAA.

Other projects considered at that time were ocean pollution, instrumentation standards, data buoys, aquaculture and mariculture, fish protein concentrates, and man-in-the-sea.

Then in January, 1972, a National Science Foundation-sponsored workshop brought together researchers from many nations, all interested in pursuing studies of the Mid-Ocean Ridge. For the first time, the outlines of what was to become Project FAMOUS were drafted by working scientists, including both Dr. Heirtzler and Dr. Keller.

Later in 1972 the U.S.-French Cooperation in Oceanography held its first formal meeting following the planning resulting from the 1970 initiative. Dr. Robert M. White, NOAA Administrator, and Yves LaPrairie, Director-General of CNEXO, led the teams from their two countries at the meeting, which was held in Brest and hosted by CNEXO. By this time Project FAMOUS had received its name, and preliminary scientific and surveying work was being undertaken by France's R/V CHARCOT, America's R/V ATLANTIS, and others.

The French scientific leader of the man-in-the-sea cooperative project at that time was then-Commandant Claude Riffaud. Dr. Riffaud later became French Scientific Leader of Project FAMOUS.

NOAA's Atlantic Oceanographic and Meteorological Laboratories were the scene of the second annual meeting of the U.S.-French Cooperation in Oceanography, held May 7–9, 1973. Dr. White and M. LaPrairie announced plans to increase significantly their cooperative programs in six areas, of which one was the Mid-Atlantic Ridge. The program outlined for Project FAMOUS at that meeting included a narrow-beam survey in the vicinity of the dive site by the French Navy ship D'ENTRECASTEAUX, a United States operation to tow an undersea mapping device, plant bottom buoys and markers, and make other observations, and deployment of bottom seismographs and mosaic mapping by the British ships SHACKLETON and DISCOVERY.

Later in that year French bathyscaphe ARCHIMEDE made seven dives on the ridge, affording man his first look at the great undersea mountain system.

The Centre Oceanologique de Bretagne at Brest was the site of the third annual meeting of the U.S.-French Cooperation in Oceanography, shortly after conclusion of the FAMOUS summer operations. Dr. White and M. La Prairie described Project FAMOUS as a highlight of the year, and agreed to examine possibilities for cooperation in additional plate tectonics studies using submersibles. They also announced plans to initiate cooperative activities in examining techniques for controlling oil discharges from ships as part of the marine pollution investigations, to begin cooperative research in coastal processes, and to consider studies involving methods of converting wind and temperature differences, currents, and tides to useful energy.

surveys. ALVIN's position relative to the transponders was calculated by a computer on board its support vessel LULU. The sophistication of the system permitted plotting on bathymetric charts so that ALVIN could be easily tracked in real time.

As they reviewed the details of each dive's traverse, the scientists showed a tremendous amount of excitement. As Ballard has said, "It took a couple of dives to get over the 'oh wow!' feeling and begin to think about the meaning of what you see in a total context of sea-floor spreading."

In general the topography was extremely rough with constant pillow lavas, ridges, and downfaulted scarps. Sharp pinnacles of lava created a serrated effect along the ridge approaching the summit of Mt. Pluto. The stepped wall on the west side of the valley often had scarps as great as 100 meters—sheer walls mostly of truncated pillows lavas.

Most of the valley floor, they found, is covered with extrusive lava formations less than 100,000 years old. Where lava has been extruded on relatively flat slopes, the shapes are very round forming "bulbous" pillows. As the slope increases, the lava flows are elongated as "Cousteau" pillows and on very steep slopes the form is ribbon-like. Point sources of volcanic flow are seen as "haystacks" with fingers of lava draped over the crest.

Near the base of the walls great lines of cracked and broken fresh rock give clear evidence of abundant earthquake activity, with little erosion except for shattering of the layer of delicate glass surrounding the fresh sea floor rock. Near the base of the steep western wall intrusive dikes of lava were observed.

Along the base of the east wall of the inner rift valley, pilots noticed a northeast water current, which is not apparent along the western wall. This current on the eastern side of the valley is in agreement with data obtained from current measurements made during the fall of 1972 and 1973. Once the pilots were aware of the current, they were easily able to compensate for its less than a quarter knot flow in maneuvering the submersible.

Research results from the Scripps Institution Deep Tow cruise and the Navy large-scale LIBEC photographs of the bottom had prepared the scientists for lineations of some kind on the sea floor. In actually traversing the rift valley floor, they were impressed by the shape and extent of many of these lineations, which turned out to be fissures in the floor and which were apparently caused by tectonic earthquake activity. Near the center of the floor these were narrow cracks, but towards the inner rift wall they became much wider, sometimes as much as 50 to 70 meters across and greater in length than the submersible traversed in any one dive.

Often the fissures are lens shaped, so that a fissure appearing minor in size may open into a crack the submersible can explore. On the ninth dive, working in a depression 500 meters northeast of Mt. Pluto, scientists Bryan and Moore with pilot Donnelly found one of several fissures wide enough to drive into with ALVIN.

"Now there's a large fissure! So large we ought to turn and get a bearing on this one . . . appearance on these fissures is that they are slightly down-dropped on the eastern side . . . This one we can go down into." Moore was recording his observations on tape.

"Let's do just that," commented Bryan in agreement. In a few minutes they were

Photo: Michael Schofield

Photo: CNEXO

Photo: Michael Schofield

Photo: CNEXO

LULU's bridge is crowded during Project FAMOUS planning (top photo). From left, Gilbert Bellaiche of France; ALVIN chief pilot Val Wilson; Dr. Wilfred Bryan; pilot Dudley Foster (with pencil); and U.S. chief scientist Dr. James Heirtzler. Below, French submersible pilots, scientists, and technicians relax on deck of bathyscaphe ARCHIMEDE between dives during 1973 reconnaissance operations.

down inside it. "We seem to have a close view of the wall on either side—close enough to see manganese coating on these pillows. The temperature probe is showing an increase . . . we're settled down as deeply in it as we can, essentially resting on both walls of it!"

Several times exploration of a fissure included taking samples of pillow lavas from the depths of the fissure. The scientists confirmed that a significant amount of lava has been erupted from these fissures east and west of the central high areas first recognized as recently active volcanic peaks.

In Fracture Zone B to the south, prior surveys pointed to a 1200 fathom trough between two deep holes adjoining the offset segments of the rift valley as the most active area of the fracture. However, on two dives thoroughly exploring the trough, scientists encountered undulating, manganese-coated sedimentary terrain.

"We're stopping on another rock outcrop, much jointing—rock is jagged, smashed, shattered! . . ." Dr. van Andel was recording his impressions on Dive 532 in Fracture Zone "B". "We're taking a sample of near-vertical slabs which protrude about ten inches. This is the same stuff! . . ." Time and again, features believed at first to be rock outcrops were found to be semi-consolidated sediments and rock talus. "It's bedded consolidated sediment! Material is very soft! Pry bar sinks right into it! . . . The material is just held together by manganese."

Scientists were impressed by the amount of bottom life in this area, far in excess of that seen in the rift valley. Also the bottom temperature was significantly lower than in the rift valley. But geologically, they were unable to learn much of the structure of the fracture zone because of the heavy sediment obscuring structural features.

The French working in Fracture Zone A did find evidence of the process occurring in these transform faults. On an early dive by CYANA, after the French scientists had reviewed the work done by KNORR earlier in the summer, the French found a deposit rich in iron and manganese that they believe may be caused by geothermal "hot springs". The U.S. scientists on KNORR spent several evenings going over the French dive area with their camera/thermal equipment to try to get better temperature measurements across the site, and even lent the French a thermal sensor that could be mounted on CYANA. However, U.S. scientists were unable to locate conclusive evidence of a geothermal geyser or hot spring.

Later in the summer, the French found several similar deposits which they documented with photographs and samples. Dr. Heinrich Holland of Harvard is carefully reviewing his temperature data to analyze it for minute changes in temperature that may be indicative of thermal anomalies. Because hot spring water would be very quickly dispersed into surrounding waters even a tenth of a degree centigrade or less might be important evidence.

Communications among all the research vessels in the FAMOUS area was frequent and there were an incredible number of transfers in rubber Zodiacs between vessels as the French and Americans met together to discuss operations and scientific findings. To celebrate the respective national holidays (July 4th and Bastille Day) there was an exchange of elaborately decorated cakes.

The French and American approaches toward the research and the results are different and each country has respected the other's way of operating. Each group will prepare a report reviewing its operations and preliminary results, and the two will be published together. As project scientists review the data, collaboration with the French will continue.

Because of volcanic activity in the rift valley is very local at any given time, the lava flows from one place to another vary. Interpretations of precise occurrences may be divergent simply because of the particular features that have been observed. But the overall picture of sea-floor spreading—the motion of the plates, the process of accretion, the formation of possible future mineral resources—has been greatly enhanced by the research carried out by the French and Americans during Project FAMOUS.

County moratorium on development follows Sea Grant students' plan for

Protecting The Currituck Banks

BY DIXIE BERG*
Photos: Les Thornbury

If for some reason you wound up on Highway 168 south out of the urban sprawl of metropolitan Norfolk, Va., you might wonder where the 20th century went.

Highway 168 takes you into Currituck County, North Carolina's most northeastern outreach. It winds through such places as Moyock, Sligo and Currituck, tiny towns free of the clutter of monstrous shopping malls, plastic signs alit with neon, or even a stoplight. The fact that Highway 168 is paved might be your only reminder that outside Currituck you live in an era of fast food and credit cards.

That's the mainland of Currituck. Yet there's an even more remote part to this rural county, a part that bears the stamp of no particular year of age. So far, it has remained almost timeless. From the mainland, you can get to the tiny sliver of sand called Currituck Banks only by boat. Four-wheel-drive vehicles are required if you're coming from Dare County beaches to the south or Virginia from the north.

On Currituck Banks, human life numbers less than 100, roads are simply tracks left in the sand by jeeps, beaches are wide and wildlife is abundant. A lone telephone booth serving the 35 residents of the town of Corolla is virtually the only clue that you haven't stepped back to an earlier age.

But while 20th century trademarks are few on Currituck Banks, pressures to turn this unspoiled, 23-mile long strip of beach into a series of fancy resort developments have multiplied over the past decade. Developers snatching up and selling plots for condominiums and cottages have sought to make Currituck the end of their rainbow. In six years, more than 50 per cent of the banks were bought by developers. And with urban dwellers from the burgeoning Tidewater, Va. area spilling onto North Carolina shores and with overly developed beaches to the south pressing northward, a place like Currituck could be no less than a big seller.

While many economically-depressed coastal counties might have jumped at the chance for an immediate increase in the local tax base, Currituck took the opposite stance.

Dixie Berg is Information and Communications Specialist with the University of North Carolina Sea Grant Program

A comprehensive land-use guide to protect North Carolina's Currituck dunes (above) from uncontrolled development will allow man to live in his environment without wrecking it. A major aim of the plan is the protection of marsh and wetlands—the nesting grounds of waterfowl (right).

In June, 1972, the county board of commissioners clamped a one-year moratorium on development and instructed county planners to employ a consultant to come up with a comprehensive land-use guide. Currituck's action is especially significant in a state where only seven of 100 counties are totally zoned and where to many rural citizens government regulation of how a man uses his land smacks of a police state.

Announced in June, 1973, the guide that was developed, known as the Currituck Plan, has been heralded by some planners as the most advanced beach development guide in the country. It is designed to protect the fragile banks from the destruction of haphazard, uncontrolled development and to maintain Currituck's major asset—its natural beauty.

Certainly one of the most unspoiled stretches of beach remaining on the east coast, Currituck Banks has for centuries taken the brunt of the Atlantic's fury. The sandy barrier is a key component in the system that makes Currituck Sound one of the finest largemouth bass fisheries on the eastern seaboard. At some points, the sandy barrier is barely 2,000 feet wide from the Sound's fresh waters to the ocean.

It was partly the clanging of survey chains and the clamor for new subdivisions that awoke the citizens of Currituck's sleepy villages to the stark realization that dramatic changes were afoot. But a great deal of the stir to save the banks was created by a college student by the name of Leslie Thornbury. It was largely a project carried out by Thornbury and fellow North Carolina State University students and faculty that sparked Currituck's decision to halt development.

During the summer of 1971, developers scrambled to grab up valuable Currituck sands. Thornbury, who had grown up in the Piedmont city of Raleigh, was spending the summer in Manteo, a town 30 miles south of Currituck. By night the NCSU student was a singer-actor in *The Lost Colony*, an outdoor drama re-enacting Sir Walter Raleigh's ill-fated English colony that settled Roanoke Island in 1587. By day, Thornbury worked on a survey crew. His evening work must have left the drama of the area's emotion-filled history firmly implanted, while the surveying job gave a first-hand view of the banks as they are today and as they may be tomorrow. Both jobs added up to Thornbury's deep attachment to the coast.

A project in a fall semester course on "Man and the Environment" gave Thorn-

bury a chance to get back to the coast and to Currituck. His project, a survey of the county's resources and land purchasing patterns, caught the eye of NCSU faculty members.

Assistant professor of zoology Dr. G. T. Barthalamus was one who took Thornbury's project seriously. Together he and R. R. Wilkinson, head of NCSU's landscape architecture department, sought funds to help Thornbury develop a plan for Currituck's growth. A $3,000 grant from the North Carolina Adult Environmental Education Program was awarded for the project in late 1971. A multi-disciplinary committee of students and faculty was appointed to work on the project. Thornbury served as director.

Having limited funds, Thornbury turned to university sources for help with data gathering and for expertise in developing the planning guide. The University of North Carolina Sea Grant Program responded with assistance by its Sea Grant investigators.

Sea Grant researchers Drs. B. J. Copeland, now Program Director, and John Hobbie provided technical assistance in collecting and analyzing nutrients in Currituck Sound. Sampling Currituck waters for nitrogen and phosphorous was a natural extension of their Sea Grant-supported research into the fate and effects of nutrients in the Albemarle and Pamlico Sounds south of Currituck.

Dr. C. Ernest Knowles, a geoscientist engaged in Sea Grant-funded research of currents and water circulation in Pamlico Sound, twice took current meters to Currituck to gauge water movements over 24-hour periods.

Sea Grant researcher Dr. Ernest D. Seneca, NCSU botanist who with soil scientist Dr. W. W. Woodhouse has investigated dune stabilization with vegetation, also answered the call for help. Seneca's analyses of what could and couldn't be wisely done on the Currituck dunes provided the basis for recommendations included in the plan.

"Les was everywhere looking for help," said Copeland, recalling Thornbury's persistence. "That plan was completed simply because he was willing to run around and coerce people to help," Copeland added.

A film recently produced by Thornbury which surveys the past and present and looks to the future of Currituck was supported by UNC Sea Grant.

The Currituck Plan as designed by the student-faculty committee was released in May, 1972. Former Secretary of the Interior Stewart Udall attended a presentation on the plan at North Carolina State University and toured Currituck with the plan's authors. A month later the Currituck County Commissioners declared a halt to development.

A combination of the student plan and the constant demand for new subdivisions which prevented any long-term, total planning prompted the moratorium, according to Jerry H. Hardesty, chairman of the Currituck County Planning Board.

Raleigh architectural firms Envirotek and Design Workshop were hired to draw up the county's official land-use plan. Students and faculty who had launched the early project acted as consultants. Grants from state, local and private sources financed the plan, which cost the county around $100,000.

To prevent additional destruction of the fragile Currituck Banks (top), no construction on or in front of the foredunes will be permitted. A single stump (below left) is evidence of an ancient maritime forest, a historic feature that should be preserved under the Currituck land-use plan. Dramatic changes to the 2,000 foot wide sand barrier (below right) illustrate the necessity for constant vigilance.

Based on the principle that a specific design concept will assure orderly development and prevent destructive exploitation of the area, the Currituck Plan was released in June, 1973. The day following the plan's unveiling, a Virginia-based developer, Coastland Corporation, announced a $125 million development to be built south of Corolla. Plans for the Ocean Sands beach community had been revamped to fit the Currituck guidelines, at much expense to the developer. State Secretary of Natural and Economic Resources James E. Harrington lauded the proposed development as a model for other coastal developers. "The Currituck Plan and the plans for this community signal a new beginning for ecology and esthetics in coastal North Carolina," he said.

Thus far, little construction has taken place on Currituck Banks, largely because access remains limited to four-wheel drive vehicles. As communities begin to spring up, they will be built with the aim of reconciling man's activities with the fragile coastal environment.

A bulldozer (top), nudging its way through Currituck's sands, is an early sign of changes coming to this remote beach. Les Thornbury's survey of the area's resources and land purchasing patterns sparked County officials to call a halt to development. Thornbury (below left) and three students of landscape architecture—Jim Thiem, Brian Sigmon and Stan Williams—participated in the original project.

Currituck's wide open spaces are a key to its natural beauty. A major aim of the plan is to maintain large open areas, while allowing for homes and services to accommodate the thousands expected to live in and visit Currituck in the future. Developers are encouraged to build cluster units, housing and businesses that serve more people in less space. Clusters would eliminate much of the sprawl and strip development that accompanies "checkerboard" communities, leaving more areas uncluttered and available to more people.

High density cluster developments better lend themselves to centralized water and sewage systems, a requirement for all future Currituck Banks communities. Individual septic tanks and wells—in an area where water supplies are close to the surface and are highly susceptible to pollution from septic tank fields—have resulted in serious water-quality problems in other coastal areas. The Currituck Plan seeks to avoid this. It further recommends that sewage be highly treated and sprayed over open areas.

Dunes, wetlands and marsh—all vital in the Currituck environment—will be preserved. No houses will be allowed on or in front of the foredunes. Most development will be centered in the more stable backdunes area. Marsh and wetlands—important as nesting sites for many waterfowl and as a vital source of nutrients for many fish and shellfish—will be protected from development activities.

Full implementation of the plan's recommendations has been slowed by two stumbling blocks—the question of access to the banks and the purchase of lands for a public park.

Although the state Department of Transportation endorsed recommendations that a system of ferries provide access to Currituck Banks, a final decision has not been reached. The Plan's authors fear that a road built connecting beaches to the south with Virginia will promote unsightly strip development. The banks would become a "thoroughfare" beach instead of the "destination" beach planners envision and the Currituck mainland would still lack access to the banks.

Critics of the Currituck Plan have charged that it will lead to a series of resort communities that exclude the less than affluent. But to insure the public's right to one of the state's most unique natural areas, the Plan urged that the state purchase a large piece of land north of Corolla, called Monkey Island, for public parkland. Although the owner wanted to sell the land to the state—and offered a price tag one-half million dollars less than developers were willing to pay—the state could not afford to buy the land. Texas-based developers have now purchased Monkey Island. With the loss of the public land, Currituck planners now believe the success of the plan is in jeopardy. According to Thornbury, the spirit of the student project has been lost if public lands are not purchased.

Developers have shown strong support for Currituck's land-use plan and are reported to have contributed some $50,000 to the county to pay planning costs. Well planned communities provide economic gains for developers and the public, according to Currituck planners. Residents benefit from an improved environment and developers, becoming total community planners, benefit from an investment that pays off longer. Centralized housing and commercial areas reduce the need for costly roads and utility installation.

With the plan, Currituck stepped well ahead of most other coastal North Carolina counties in meeting requirements of the state's Coastal Area Management Act. A major provision of the 1974 law calls for counties to develop a comprehensive plan for development.

The Currituck Plan marks a significant beginning. It was an unusual effort that brought students, faculty, local and state representatives and developers together on a common goal—the conservation of a unique natural area. The birth of the plan brought to coastal North Carolina the idea that good planning can allow man to live in his environment without wrecking it. But as of now, the Currituck Plan remains largely a scheme laid out on paper. Only as it is put into action can its merit be proved.

GATE's history-making summer of '74

Success Story In Senegal

BY CARL A. POSEY PHOTOGRAPHY BY FRANK OXLEY

"ALL U.S. PLATFORMS ARE NOW RELEASED TO THEIR PARENT ORGANIZATIONS. PHASE III HIGHLY SUCCESSFUL. OF THE 1400 MEMBERS OF THE U.S. COMPLEMENT ASSIGNED TO GATE THERE WERE NO SERIOUS INJURIES, DISABLING INJURIES OR DEATHS. AS OF THIS DATE THERE HAS BEEN NO CIVIL CONVICTION AGAINST ANY U.S. CITIZEN. THERE HAS BEEN NO LITIGATION INVOLVING U.S. MEMBERS OR THE UNITED STATES AND NONE IS PENDING. THE OBJECTIVES OF INTERNATIONAL COOPERATION AND INTEGRATION AND SAFETY HAVE BEEN MET. THE MOST CONSERVATIVE OF ALL INTERNATIONAL SCIENTISTS REPORT THAT THE SCIENTIFIC DATA OBJECTIVES OF GATE HAVE BEEN ACHIEVED. TACTICAL COMMUNICATIONS WERE DISCONTINUED ON 242200Z. THE GATE COMMUNICATION CENTER WILL BE DISCONTINUED UPON DEPARTURE OF THE LAST USCG LOGISTICS FLIGHT. WILL LEAVE SMALL RESIDUAL STAFF FOR PAYMENT OF BILLS AND PROPERTY TRANSFER TILL 4 OCTOBER. THE U.S. FIELD OFFICE WILL CLOSE AT 27000Z AND I WILL RELINQUISH MY DUTIES AS DIRECTOR AND NATIONAL COORDINATOR FOR THE UNITED STATES AND CANADA AT THAT TIME. IN CONCLUSION THE TOTAL MISSION ASSIGNED BY THE ADMINISTRATOR NOAA AS THE U.S. LEAD AGENCY FOR GATE BY OPERATIONS PLAN 1-74 HAS BEEN ACCOMPLISHED. THIS IS THE FINAL REPORT FROM THE U.S. FIELD OFFICE EXCEPT FOR FURTHER SHIP AND AIRCRAFT ARRIVALS AND DEPARTURES. I AM GRATEFUL FOR THE COMPLETE AND UNSTINTING SUPPORT OF ALL AGENCIES AND THE GPO AND HOPE THE FINAL SCIENTIFIC RESULTS BEAR OUT THE CURRENT OPTIMISTIC APPRAISAL OF THE SCIENTISTS. BARNEY."

With this cable Col. William S. Barney, Director of U.S. Field Operations for the Global Atmospheric Research Program's Atlantic Tropical Experiment, wrote finis to GATE's field phase in Dakar, Senegal, on Sept. 25, 1974.

For about 100 days, the GATE Operation Control Center, or GOCC, near Dakar's Yoff Airport, had been the scene of man's most ambitious effort to understand the processes occurring in and over the tropical ocean—processes which ultimately drive much of the world's weather. Sponsored by the United Nations' World Meteorological Organization and the International Council of Scientific Unions, GATE was the first major international experiment in the Global Atmospheric Research Program. It was done in an oblong about 28 degrees wide, stretching from Mexico eastward to the Persian Gulf, and reaching from a thousand meters below the ocean surface into the high upper atmosphere.

Twenty million square miles.

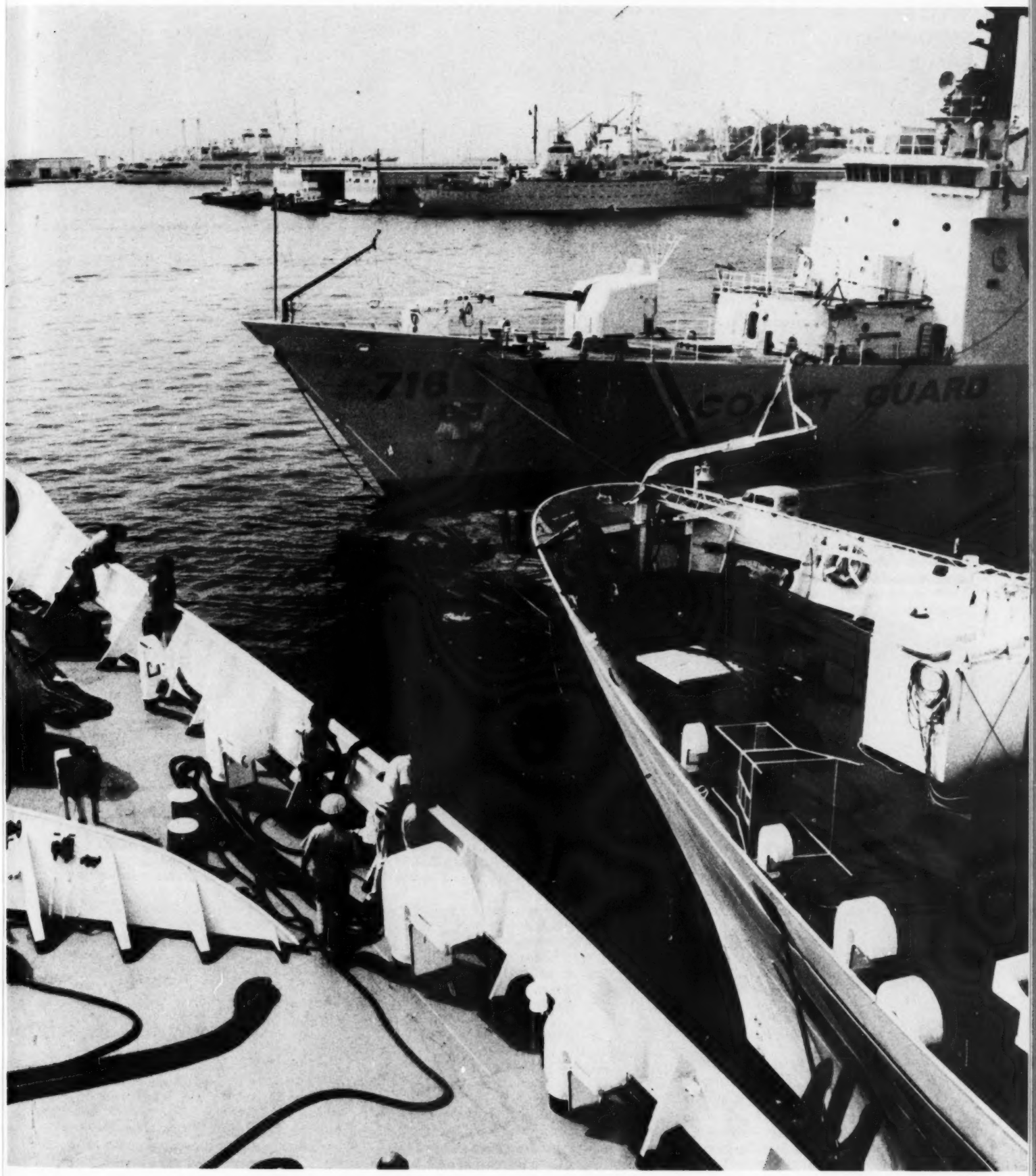
Land stations on two continents interrogated the atmosphere on rhythms determined by GATE planners. In the uninstrumented ocean area—the region where solar energy fuels the complicated engine of world weather—an international fleet of 40 ships was arrayed and equipped to measure, in three, three-week-long periods, processes in the upper layers of the ocean and the atmospheric boundary layer, all with uncommon precision.

The arrangement of the GATE array was important. A key factor in this study was the Intertropical Convergence Zone, the cloudy band which marks the meteorological equator, a region of weather where the solar energy and ocean and air currents of two hemispheres meet, mingle, and are mutually influential. The ITCZ, as it is called, is a powerful wild card in the earnest game of weather prediction.

GATE was designed to capture the physical moods of this interhemispheric borderland of the atmosphere, at every significant scale of time and space. The experiment's first field phase began just after the northern hemisphere's summer solstice, with the ITCZ at its northern limit. Thereafter, following the sun toward the equator, the zone shifted southward, carrying its parcel of secrets across the array of waiting ships and buoys, pursued by aircraft from Dakar, monitored by satellites. If it is possible for technology to reveal the natural world, last summer's experiment should bring comprehension of this meteorologically crucial region.

The nerve fibers radiating out from the GOCC took the form of communications—sophisticated radio links between scientists and operations people in Dakar and the farflung ships and aircraft which made up the experiment. Operated by 20 men of the U.S. Coast Guard, five radio operators from the

NOAA Ships OCEANOGRAPHER (left) and RESEARCHER ride with Coast Guard communications ship DALLAS in Dakar's harbor.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GATE GALLERY: a random sampling

Dr. Robert Burpee
Weatherman

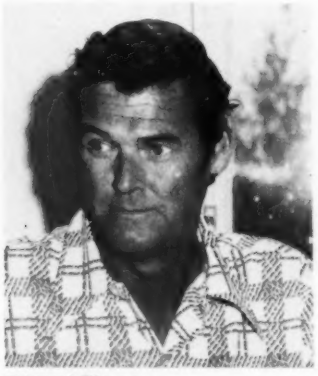
Col. William S. Barney
U.S. Field Director

Raymond Hogan
Finance Chief

Dr. James Rasmussen
Chief, U.S. Science Group

LCDR. Andrew Durkee, USCG
Communications Chief

Kristyne Loughran
Staff Assistant



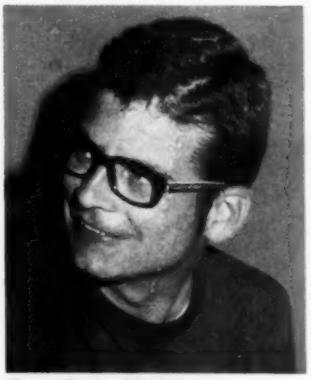
Edward Tiernan
International Operations Planner

John Willis
Conferences and Briefings

Cdr. Sigmund Petersen
Control Center

Miriam Kluth
Office Manager

Loran Weaver
International Aircraft Operations



Terry De La Moriniere
International Data Management

Maude Valentine
Secretary

Don Seeko
U.S. Field Coordinator

Glenn Garte
Personnel/Administration

LCDR. Thomas Ruszala
International Port Coordinator

Senegalese and United Nations flags fly at GATE Operations Control Center near Yoff Airport. GOCC was nerve center of GATE operation, including communications (see array at top left). Modern two-story building continues in use by the Government of Senegal.

Soviet Union, and eight Senegalese teletypewriter operators, the GOCC communications center ensured that the many gears of GATE would mesh smoothly.

Besides controlling ship and airplane operations, the center collected all incoming weather reports from the GATE ships. Weather reports and meteorological data received from the ships were sent on to a special analysis center at Yoff Airport where weather experts studied them with an eye to planning GATE aircraft missions.

Weather data from the ships was also sent to the Regional Meteorological Center at Yoff Airport, responsible for weather forecasting for the entire Atlantic portion of the GATE area. A global telecommunications system relayed data to World Meteorological Centers in Washington, D.C., and Moscow, where weathermen added it to the daily puddings from which global, long-term weather forecasts are produced.

The ocean-going counterpart of the communications center at Yoff Airport consisted of rather comprehensive radio shacks aboard relay ships in the GATE array—the Coast Guard cutter *Dallas,* and four of the Soviet ships. These provided a filter between Dakar and the anchored ships of the GATE arrays.

The ships, with instruments on bow-mounted booms, boundary-layer instrument pods strung from Volkswagen-sized balloons, oceanographic casts, special radars, rawinsonde launchings, meant that the desert of the tropical Atlantic had been populated by advanced oceanographic and meteorological observing stations. From these arrays, set up to measure processes at large, medium, and small scales of time and space, the conventional measurements were made that will eventually find their way into the new computer models waiting to be tested.

But there was a good deal of unconventional sensing as well.

A new sound on the OCEANOGRAPHER was a case in point. Every five seconds, three horn antennas mounted near the bow of the NOAA ship OCEANOGRAPHER emitted a high-pitched tone with a decibel level near the human threshold of pain.

The sound waves travelled through the atmosphere until they struck a temperature change, which scattered and bounced them back toward earth.

The atmospheric acoustic echo sounder, designed at the Wave Propagation Laboratory in Boulder, Colorado, provided a record of winds and temperature structure to a height of 400 meters (1300 feet) that will form a key piece in the gigantic GATE puzzle.

Developed and built by Dr. Peter Mandics under the leadership of Dr. Freeman Hall, the acoustic sounder was the only instrument of its kind gathering data aboard ship during the massive project.

The system was installed on the OCEANOGRAPHER in three large box-like transmitter/receivers—one aimed straight up into the atmosphere, and two angled outward from the ship's bow. Each contained a 100-watt industrial speaker, similar to those used in sports stadium public-address systems.

At five-second intervals, the transmitters sent a 200-millisecond (one-fifth of a second) blast of sound into the atmosphere. Then, after a pause of 50 milliseconds to allow the transmitter to stop oscillating, the receivers began listening for returning sounder echoes.

Temperature changes at any level within the 400-meter range scattered the sound bursts and returned them to the receivers. In warm, rising air, the returning signals were strong; in cooler air, they were weaker.

"The human ear is an excellent acoustical instrument," Dr. Hall says, "but our equipment can hear 10,000 times better." So sensitive are the receivers that raindrops strike them with a loud bang.

On the ship, the returning echoes were converted to electrical signals and recorded automatically on a 14-channel tape recorder, as well as by facsimile equipment, giving a picture of the temperature structure of the atmosphere. Wind profiles—vertical tracings of wind speed and direction at various levels—were calculated later, by analyzing the Doppler shift of the returning echoes. In this way, wind speed and direction can be computed for thirteen 30-meter-thick levels in the lowest layer of the air.

The acoustic soundings also contributed to the GATE investigation of the transfer of energy from sea to air. Warm air rising from the sea in tropical convective systems returned a strong signal to the shipboard receivers. When such a system moved over the antenna array, its shape and structure were recorded by the sounder.

Buoys played an important role in GATE (28 were put out and most of them recovered) especially to test some new ways to measure conditions in the ocean's boundary layer.

During the third and final phase of the experiment, a white "fish" the size of a dolphin with a head like an old-fashioned diving helmet joined the research fleet.

Called "Cyclesonde" by its inventor, Dr. John Van Leer of the University of Miami's Rosenstiel School of Marine and Atmospheric Science, the creature is designed to travel up and down a cable, on a taut wire

Major ships in GATE fleet (facing page) includes NASA's VANGUARD (top left), Canada's QUADRA, USSR's PORYV (center left), France's JEAN CHARCOT, and NOAA's RESEARCHER (bottom). Above Dr. H. Guyford Stever, Director of National Science Foundation, releases weather balloon from shipboard.

mooring, sound the upper 200 meters of water in the same way a balloon sonde is used to sound the lower atmosphere. This comparatively shallow, 200-meter layer of the ocean was critical to GATE investigators, especially those concerned with the small (10-100 kilometer), shortlived "C-scale" phenomena of the tropical Atlantic, the scale of greatest emphasis in GATE's third phase.

The Cyclesonde used last summer was the second and most advanced model of the system, whose development had received support from the National Science Foundation and NOAA.

The electronic mind of Cyclesonde vents or draws compressed helium from the tank to change its buoyancy, causing it to rise or sink. Depending on the frequency of the dives, Cyclesonde can be left to prove the ocean's surface boundary layer for as much as a month at a time.

With Cyclesondes aboard the ISELIN were Drs. Van Leer and Henry Parkins and Cyclesonde electronic engineer Andrew Costello and technician Dale Dupuis, of the University of Miami, and Dr. Ants Leetmaa, of NOAA's Atlantic Oceanographic and Meteorological Laboratories in Miami.

Solar energy is the "current" which sets the awesomely complex, planet-sized weather system in motion, making solar radiation measurements a kind of scientific keystone to the understanding GATE sought.

Halfway through last summer's experiment, it had become apparent that this complicated solar power plan was yielding some of its closely held secrets to the international team of radiation specialists and their carefully tuned instruments. The black and white, target-like sensors called pyranometers aboard 30 ships—10 from the U.S.S.R., seven from the United States, and 13 from other nations—were sensing incoming solar energy with rare accuracy and detail.

The work of ensuring that this keystone, as fashioned by sensors aboard 30 ships of different nationalities, would fit began more than two years ago.

A pre-GATE intercomparison conducted at sea in August 1973 pointed up the fact that there were large differences between solar radiation sensors aboard ships exposed to the same radiation conditions—but that these instrumental differences were systematic enough to be correctable, through sensor intercomparisons at sea during GATE.

This cooperation took form in early 1974, at NOAA's Atlantic Oceanographic and Meteorological Laboratories in Miami.

There, some 60 pyranometers from Brazil, Canada, the Federal Republic of Germany, France, Mexico, the United Kingdom, U.S.S.R., and United States were operated simultaneously, and their records intercompared. The Canadian pyranometer standard provided the standard for this intercomparison.

Dr. Kirby Hanson, the NOAA scientist coordinating the United States GATE radiation study, noted that the Miami intercomparison helped achieve good agreement between the pyranometers of the nations participating in GATE.

"A year ago," he said, "pyranometers on two ships in the pre-GATE intercomparison array showed radiation differences of as much as 20 percent. Thus far in GATE, our intercomparisons are showing differences of only two to three percentage points between as many as 10 ships.

"The practical result of this," he explained, "is that we are able to observe variations in solar radiation from day to day and phase to phase which might have been 'masked' by the differences introduced by non-standardized instrumentation."

During phase three, GATE scientists ran a topographic survey of the ocean around the C-scale ship array, to determine how the surface texture of the sea affects the exchanges of energy and momentum between the ocean and atmosphere.

Coordinated for GATE by Dr. Klaus Hasselmann of the University of Hamburg, the wave experiment combined sensors aboard aircraft and an array of ship-launched buoys to obtain a uniquely detailed view of the surface structure of the tropical Atlantic Ocean.

The phenomena of greatest interest were waves with lengths ranging from one to 500 meters—the high-frequency surface events of the sea, from light choppiness to swells. The frequency distribution of waves in this range is known to be important to mixing processes in the upper few hundred meters of the ocean, but the details of this relationship are not well understood. Nor are the links between events in the mixing layer and the ocean's ability to yield up heat energy to the atmosphere.

Six ships participated in the wave buoy experiment—Canada's QUADRA, the Federal Republic of Germany ship METEOR, the University of Miami's JAMES M. GILLIS, the Texas A&M University ship FAY, and NOAA's OCEANOGRAPHER and RESEARCHER. In addition, four Soviet ships—the ACADEMICIAN KURCHATOV, PRIBOY, PROFESSOR ZUBOV, and ACADEMICIAN KOROLOV—took data with hull-mounted wave sensors.

Each of the buoy ships launched two floating systems designed to measure different aspects of ocean wave motion. A British-developed pitch and roll buoy, shaped like an open cone about four feet across the base, senses the frequency and direction of wave action. The Dutch-developed wave-rider buoy is a moored sphere three feet in diameter, designed to measure the up and down motions of waves passing its station. The pitch-roll buoys were tethered to their ship, and passed data long an electrical line running along the tether. The wave-riders relayed their data to the ships by radio telemetry.

Two aircraft—a Navy P3A from the Naval Oceanographic Office and a DC-6 from NOAA's Research Flight Facility in Miami—made daily runs near the area occupied by the ships and buoys, profiling the ocean surface with a laser device from altitudes of 300 to 500 feet.

Duncan B. Ross, coordinator of the aircraft portion of the wave study from NOAA's Atlantic Oceanographic and Meteorological Laboratories, noted that the study was the first of its kind.

"Waves are an important part of the world weather problem," he explained, "but just how they fit into the problem has never been studied in any systematic way. This investigation should give us some specific quantities to use in determining how waves are related to the processes which move energy and momentum from the ocean into the atmosphere.

"It should also help us develop models which specify conditions—including wave conditions—in the oceanic boundary layer, and permit tests of some of the advanced wave-forecasting models the Navy has under development.

"We are getting information here that simply has not been available to scientists before this."

Working with Ross was Robert Berles, also from the Miami laboratories, in charge of the laser profilometer system aboard the NOAA DC-6. Navy chief scientist on the project was P.S. DeLeonibus.

For the Federal Aviation Administration's Robert A. Christopher and the air traffic control team he led, GATE meant keeping control of 12 airplanes whose missions required them to fly erratic paths at varying altitudes over 900,000 square miles of the tropical Atlantic Ocean.

Christopher, who lives in Bowie, Maryland, was air traffic coordinator of the GATE project, now returned to being assistant to the director of Air Traffic Service in the Washington, D.C., unit of the FAA. During the experiment, however, he and his staff operated from a special central position in the Dakar Flight Information Center at Yoff Airport.

Working with Christopher were three American and four French air controllers responsible for guiding the day-by-day air traffic. Four long-range, high-frequency radio communication channels kept them in touch with the GATE aircraft zigzagging over a GATE zone some 500 miles to the southwest.

Air travelers passing through Dakar last summer saw a strange assortment of planes lined up on the apron there.

There were two Russian Ilyushin-18's, a French DC-7, a British C-130 Hercules and, from the United States, NOAA's DC-6 and WC-130, the FAA's KC-135, NASA's Convair-990, and an Electra and a Sabreliner from the National Center for Atmospheric Research. Two more planes joined the squadron for phase three—NCAR's Queen Air and an RP-3A Orion from the Naval Oceanographic Office.

But it was not the number or even the international nature of the aircraft lineup that made travelers look twice. It was the strange bulges, protuberances, and attachments on each plane.

Some, with candy-striped booms on their noses, resembled giant stinging insects. The booms were platforms for gust probes, delicate instruments that make rapid, precise measurements of air movement and of atmospheric moisture and temperature.

There are perhaps half a dozen gust probe aircraft in the world. Three of them flew in GATE—the C-130 from the United Kingdom, the NCAR Electra, and a DC-6 from the Research Flight Facility.

At work in varying settings, Secretary Donna Johnson takes conversation verbatim aboard NASA's Convair 990; right, David Bargen of NCAR at airborne console on FAA plane; above, Oneal Thomas briefs crews on upcoming air operation south of the Equator.

Dr. Bradford Bean, who directs NOAA's Boundary Layer Dynamics Group in the Environmental Research Laboratories, helped pioneer gust probe development in the United States.

"What was needed," he says, "was an instrument system that would tell us how the air was moving, how much water it carried, and the various quantities involved in the transfer of water and energy from the ocean surface into the atmosphere, in an environment that was still undisturbed by a probing aircraft.

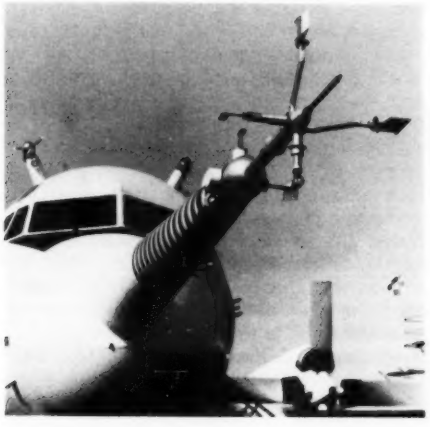
"What we have is the gust probe, which has been in use for about five years now, but which continues to evolve. It sticks out ahead of the aircraft so that it can sense boundary layer quantities a split second before the airplane arrives to disturb them. The system gives us pressure, wind motions, accelerations of the aircraft, humidity, and temperature, all to very close tolerances."

In GATE, the boundary layer researchers were constructing a uniquely detailed view of this crucial region of the atmosphere—but doing it one 20-nautical-mile-long straw at a time. It took considerable flying.

The bulges in the clean lines of the planes' fuselages at Yoff held weather radars that detect the location and intensity of clouds.

Other instruments poking through the aircraft skins included cameras, temperature, humidity, and pressure sensors, devices for recording radiation received from the sun and emitted by the earth, or samplers that take in air and count water droplets, ice crystals, or minute particles of dust.

GATE's comprehensive quality required



Exotic aircraft were order of the day at Dakar. Top, United Kingdom's C-130, replete with scientific packaging; bottom left, NCAR's Electra bristles with probing gear; at right, USSR aircraft sweeps low over the Senegal countryside in calibration flight.

many kinds of airborne exploration—flights that measured the qualities of individual cumulus clouds, of clusters of cumulus clouds, of huge waves in the atmosphere, and of the Intertropical Convergence Zone north of the Equator, where the northeast and southeast tradewinds meet. To trace the path of heat and moisture from the warm tropical oceans to higher altitudes and latitudes, the features of the tropical atmosphere had to be investigated at every stage of their life cycles—birth, maturity, and decay.

Flying at altitudes from 50 to 43,000 feet, the GATE aircraft gathered atmospheric and ocean measurements, principally over the concentrated array of research vessels several hundred miles off the west African coast. During the flights, they made intensive measurements of air temperature, humidity, dewpoint, and pressure; liquid water, nuclei, droplets, ice crystals, and icing rate in clouds; sea surface temperatures; wave heights; radiant energy; and atmospheric turbulence. Some collected aerosol samples, photographed cloud systems, recorded weather radar images, or released sounding instruments that returned information on temperature, pressure, humidity, and wind velocity between the aircraft and the sea surface.

More than 30 types of aircraft missions involving from one to eight planes were designed by an international team of scientists before the experiment began. the missions were categorized as basic GATE Intertropical Convergence Zone, post-cluster, weather disturbances near the African coast, boundary layer, oceanographic radiation, convection, cloud physics, windfinding dropsonde, and reconnaissance.

Missions flown to gather data for the basic GATE program used several aircraft, which began the first leg stacked vertically at altitudes ranging from 500 to 30,000 feet.

In addition to preplanning 30-odd aircraft missions, the designers of GATE specified the optimum number of each type of mission needed to attain the experiment's overall objectives. The total was more than 300 individual aircraft flights, to be completed by the 12 aircraft during the 100 days of field operations.

Each evening before six o'clock, GATE scientists decided on the missions to be flown after 8 a.m. the next day, allowing 14 hours' notice to the flight crews. (The infrequent night missions, between one and eight a.m., had to be planned the preceding morning.)

Five major factors governed the choice of aircraft missions. What weather systems

P. K. Govind (left), Robert Christopher of FAA, chief of aircraft control operation, and Dr. David Houghton of University of Wisconsin (right) plan data-gathering flight. Right photo, Dr. Mansour Seck, director of Senegal Weather Service and Dr. Joachim P. Kuettner, GATE Director, confer.

were expected to be in the GATE operations area? Which planes would be available? What was the status of ships in the GATE array, and of their observing systems? Which scientists would be on hand to fly in the aircraft and to coordinate the mission from field headquarters? How many of the various kinds of missions had already been accomplished?

To aid them in estimating what weather conditions would be over the GATE ships the next day, the scientists looked to the latest pictures from the Synchronous Meterological Satellite and to the prediction made by the special GATE forecasting group.

In this context, cloud pictures from the Synchronous Meteorological Satellite were invaluable. Launched in May 1974 by the National Aeronautics and Space Administration, SMS-1 was in a 22,300-mile-high earth-synchronous orbit that kept it continuously above an equatorial point in the mid-Atlantic. (It has since been shifted westward.)

From this outpost in space, the satellite viewed weather systems over approximately one-third of the earth and sent images of what it saw back to receiving stations on earth every half hour, night and day. These images provided weather information at a frequency never before available to forecasters and to the international cadre of scientists responsible for directing the field operations of GATE.

Each day, the GATE operations center received more than 80 SMS-1 images. These included at least 40 of the possible 48 hemispheric infrared images which can be acquired by the spacecraft in a 24-hour period. During daylight hours at Dakar, the center also received 20 visible picture sectors showing clouds and cloud systems two miles or more in size, in an area which spanned the Atlantic and included the continental bulges of South America and Africa. Features as small as a half-mile across were revealed in another 20 sectors covering the west coast of Africa and the eastern Atlantic area where the dense GATE ship array was located.

At Dakar, the image signals received from the United States through two leased lines were transformed into photographs by a complex collection of equipment manned around the clock by a staff of eleven.

At three-hour intervals, the Satellite Field Services Station produced four complete sets of positive prints—one for the meteorologists who forecasted weather for GATE ship and aircraft operations; another for use in special analyses of weather over the GATE area; a third for display in the conference room where aircraft missions were planned; and the remaining set for the mission scientists.

In all, five kinds of satellites gathered data for research during GATE—the Soviet Union's Meteor series, the United States' ATS-3 (Applications Technology Satellite) and Nimbus-5, in addition to SMS-1, NOAA-2, and NOAA-3. They played a pivotal role in GATE, scanning the entire experimental area and furnishing day-and-night information on cloud systems, their liquid water content, the heights and temperatures of cloud tops, speed and direction of cloud movement, temperature and moisture in the atmosphere, and sea-surface temperature.

Most GATE aircraft missions took place somewhere over the 200,000-square-mile ocean area where 14 research ships formed a hexagon-within-a-hexagon. The shipboard observations, together with those taken by aircraft and satellites above them, combined to form a detailed three-dimensional picture of what was happening in the atmosphere. In planning aircraft missions, GATE scientists considered the ships' operational status—which vessels were on station, what observations were being made, and how frequently. The ships might have been in a three-day intensive observing period, taking eight upper-air soundings per day instead of four, to record the development of a cloud cluster. And that would affect the choice, course, and timing of the aircraft mission.

Scientists in the multi-national group were specialists in certain facets of meteorology—such as synoptic or large-scale weather, convective processes, the boundary layer or lowest 2,000 meters of the atmosphere, radiation, or cloud physics. Whatever kind of mission was chosen for the next day, specialists in that field had to be available to guide the flight in the air and on the ground.

Another vital consideration was the balance among missions already accomplished. If there was a dearth in one or more areas, the scientists tried to fill the gap and restore proper proportion at the first opportunity.

Dr. Joachim P. Kuettner, GATE Director, presided over the Mission Selection Team meetings, with Dr. Yuri Tarbeev, Deputy Director, seated at his right.

National representatives on the team were Dr. Jean Alt, France; Dr. Gwynn James and Dr. Michael Nichols, United Kingdom; Dr. Helmut Kraus, Federal Republic of Germany; Dr. Alexander Borovikov and Dr. Valeri Zhalev, U.S.S.R.; and Dr. James L. Rasmussen and Dr. Edward J. Zipser, United States.

Dr. Rasmussen, a NOAA scientist, coordinated the U.S. Scientific participation in GATE. Dr. Zipser led the GATE program of the National Center for Atmospheric Research, Boulder, Colorado.

Meetings of the Mission Selection team followed a formalized pattern, beginning with operational reports on the status and availability of GATE aircraft and on the ships, shipboard observing systems, and communications.

These were followed by a presentation on

Research Flight Facility's C-130 sweeps past calibration tower at Thies in high-speed, low-level run. Instruments on planes and shipboard underwent stringent tests to insure proper calibration. Thies' tower was erected by National Ocean Survey.

the weather by Dr. Robert Burpee of the NOAA's National Hurricane Research Laboratory in Miami, or another member of the GATE weather forecasting staff. A film loop of SMS-1 pictures received every half hour since daylight was shown. The forecaster, with the unenviable task of forecasting weather for some of the world's leading meteorologists, summarized the day's weather and gave his prediction for the coming day.

A major item on the agenda was the selection of airborne mission scientists and mission scientists. An airborne mission scientist flew in a command aircraft of his own choosing, arrived at the starting point of the mission about half an hour before the other planes to pinpoint the weather system to be explored and direct the scientific aspects of the airborne operation.

The mission scientist remained on the ground, working in the GATE Operations Control Center. He or she consulted frequently with the airborne mission scientist, and passed on the latest information on cloud location and intensity acquired by SMS-1 and shipboard radar.

One of the airborne missions had the responsibility of patching holes in the GATE data acquisition scheme, for, with millions of square miles under investigation, data gaps were unavoidable.

To combat this problem, GATE scientists used a long-range aircraft carrying dispensable dropwindsondes—the FAA's KC 135. Ordinarily the plane is used for checking avionic navigation equipment around the world; but in GATE it traversed otherwise-uncovered areas deploying dropsondes to determine wind, temperature, humidity and pressure.

Armed with the latest satellite photos, the plane—named Ol' Smoky by its crew—flew frequent scouting missions, averaging perhaps 2,500 miles of over-ocean flying.

An airborne mission scientist was assigned to fly on each dropsonde mission. Frequently assigned to this task were Dr. David Houghton, professor of meteorology at the University of Wisconsin and Dr. Robert Simpson, recently retired from NOAA and now with the University of Virginia, serving GATE under National Science Foundation grants. They recorded the minute-by-minute annals of the mission on a huge map, and relayed significant observations back to Dakar, particularly those which might interest other GATE aircraft starting out on cloud-hunting missions.

The dropsonde engineering team was from NCAR's Research Systems Facility in Boulder, Colorado. It consisted of P. K. Govind, David Bargen, and Kenneth Norris. The Research Systems Facility developed the dropsondes, which differ significantly from conventional sondes: along with the traditional temperature, humidity and pressure readings, they employ the Navy's Omega navigation system to measure wind direction and velocity.

The sonde dropped 33,000 feet in 31 minutes, descending under a brilliant red parachute, "talking" constantly to the plane. The system on the KC 135 could track two sondes simultaneously; each could be tracked up to 240 miles. On a five-hour mission, as many as 10 soundings could be made.

The success of these complicated aircraft operations depended on intercomparison. A few weeks before GATE began, a NOAA team appeared at the deserted airstrip at Thies and, in five hours, erected a tower 150 feet high.

From then on, life was hardly the same for the cattle and goats grazing beside the runway. All summer, huge airplanes came in low over the horizon and screamed past the towertop at speeds as high as 340 miles an hour—as many as 18 times in a morning.

One requirement of GATE was unyieldingly rigid: instruments on the airplanes had to be precisely accurate, or their data lost its meaning. That was the Thies tower's reason for being. Dr. Joachim P. Kuettner explained it thus, his words being translated into three languages, at the first aircrew briefing June 19:

"Most of our flights will involve four to six planes at different levels. We wish to picture the atmosphere at the lowest and highest levels. It is very important to know whether the differences are atmospheric or in the instruments. They must be calibrated absolutely against the tower, and relatively among yourselves."

At Thies, three men would perch in the open tower after a rope-protected climb not meant for the fainthearted. They were NCAR's Alfred Rodi of Lafayette, Colorado, systems supervisor; Frank Alexander of Washington, D.C., from the FAA; and Hubert Martineau of France, a controller. On the ground were Dr. Henry Gertzman of NCAR and his assistant, Melvin Clark of Seattle, a recent graduate of the University of Washington.

In a towerside shack, Dr. Gertzman had an imposing array of gear: a 20-channel scanning analog-to-digital converter and data formatter, and a seven-track incremental tape transport for output. Each day's comparison of plane-versus-tower readings went at night to the GOCC to be run on a computer, under the supervision of NCAR's Dennis Joseph and Larry Sapp.

As the big ships came sweeping in, the tower, often fighting language barriers, guided them. When they found the series of bright orange markers they were to follow, they had to keep a near-precise altitude. It was very ticklish flying indeed. As the aircraft flashed past, Dr. Gertzman tripped a switch and snapped out: "Mark!." At this point the moment of truth is recorded.

Later, scientists will compare the sensings of tower instruments with those aboard the aircraft, ensuring that there is a Rosetta stone around with which to differentiate between differences caused by environmental conditions and differences caused by instrument error. Throughout GATE, instruments were compared with one another.

Since late June, large cardboard boxes have been arriving at ports and airports around the world, carrying the raw records from which such revelations will be drawn. The containers have come home to all the nations which sent a dedicated platform into GATE—Brazil, Canada, France, Federal Republic of Germany, the German Démocratic Republic, Mexico, the Netherlands, the United Kingdom, the United States, and the Soviet Union.

In the United States, Pan Am, Eastern, and the Coast Guard have flown the boxes into the Washington area—588 in all. The last arrived October 11. The boxes were met by NOAA people, and trucked out to the

Corridor briefing is given Russell Peterson, Chairman of Council on Environmental Quality, by Dr. Douglas Sargeant (left), Director of U.S. GATE Operation; and Dr. Yuri Tarbeev (center), Deputy Director of international program.

Top right, President Leopold Senghor receives distinguished U.S. delegation. From left: UN Ambassador Francis Dales; Gov. Peterson; O. Rudolph Aggrey, U.S. Ambassador to Senegal; Dr. Robert M. White, NOAA Administator; the President; Dr. Kenneth Spengler, Executive Director, American Meteorological Society; Dr. H. Guyford Stever, Director, National Science Foundation; Dr. Eugene W. Bierly, head, NSF Office for Climate Dynamics; and George Low, Deputy Administrator of NASA.

Right, Russia sends greetings to U.S. on July 4. From left, Dr. Tarbeev, Dr. Alexander Borovikov, USSR National Representative; Col. Barney; Dr. Yuri Belaiev, Director, Ship Operations.

GATE Planners

NOAA's Office of Environmental Monitoring and Prediction, under Associate Administrator Edward Epstein, coordinated U.S. activities related to the World Weather Program. The U.S. GATE Project Office planned, coordinated, and led the United States effort in the GARP Atlantic Tropical Experiment. Office officials and their responsibilities were:

Dr. Douglas H. Sargeant	Director
William S. Barney	Field Director
Walter Telesetsky	Project Coordinator
Capt. Dewey G. Rushford, NOAA Corps	Logistics
Orville E. Scribner	Systems Engineering
Dr. James L. Rasmussen	Science Coordination
Capt. Richard H. Houlder, NOAA Corps	Operations
Dr. Joshua Z. Holland	Data Management

Liaison officers from other agencies—some of whom were assigned full-time to the GATE Project Office—have included:

Dr. Eugene W. Bierly, National Science Foundation

Cdr. A. F. Durkee, U.S. Coast Guard

Lt. Col. T. M. Kaneshige, USAF, Department of Defense

Dr. T. H. R. O'Neill, National Center for Atmospheric Research/National Science Foundation

Robert Christopher, Federal Aviation Administration

NOAA coordinated and directed U.S. participation in GATE but many Federal agencies were deeply involved in the mammoth project. They included the Air Force, the Navy, the State Department, the Department of Transportation (through its Coast Guard), the National Aeronautics and Space Administration, the National Academy of Sciences, the National Center for Atmospheric Research and the National Science Foundation.

Many scientists affiliated with universities also were major participants in the experiment.

And the Government of the Republic of Senegal offered what was universally hailed as outstanding cooperation and assistance before and throughout the project.

Center for Experiment Design and Data Analysis in Rockville. They contain a kind of gold—about nine tons of assorted magnetic tapes, undeveloped film, card reports, strip charts, computer printouts, and some 60 different types of daily data form. This is the information gathered by the United States GATE ships. The last 108 boxes were picked up on the Dakar dock from the Oceanographer and Gillis on September 24, and taken out to the GOCC to begin the long trip home. Data from the American satellites—the SMS-1, NOAA 2 and 4, and ATS-3—are also flowing into CEDDA.

At the National Center for Atmospheric Research in Boulder, some 400 rolls of magnetic tape and some 600,000 photographs of clouds and radar scopes have come in. These are the airborne data taken by the American aircraft which flew for GATE.

CEDDA and NCAR, and their counterpart organizations around the world, are taking a first cut at the raw data. In what resembles a farming operation, the data are being sorted, cleaned, intercompared, and put into an attractive but still raw form.

Data. The yield from GATE is something over 13 billion bits of data, digital natural history from satellites, ships, buoys, aircraft, and land stations. From the beginning, scientists from NOAA and other organizations, here and abroad, have tried to shape the mountain of GATE data as it grew. Data managers went with the ships, flew aboard aircraft, "tasted" incoming data for utility, all to ensure that the mountain would be worth the climbing for a generation of scientists.

The overall GATE data plan reflects the central program, which, greatly simplified, can be called a search for a way to estimate the effects of small-scale tropical weather systems on larger ones, and so to improve and verify numerical models of tropical weather. But it also reflects five very active subprograms: synoptic-scale, boundary layer, convection, radiation, and oceanography.

Once the national processing centers—NCAR and CEDDA in the United States, for example—complete the examination of their data, an elaborate international exchange moves the material to World Data Centers in Washington, Moscow, and Melbourne for assembly into what will eventually be full sets of processed GATE data. Data also flow to subprogram data centers—synoptic scale to Bracknell, boundary layer to Hamburg, convection to Washington, radiation to Leningrad, oceanography to Brest—for further reduction and ordering into specialized data sets useful to a wide scientific audience.

What will all this buy the 70 nations participating in GATE?

The immediate answer is that GATE data should improve scientific understanding of processes in the tropical ocean and atmosphere enough that the links between events there and global weather are revealed; and this, in turn, should extend the life and accuracy of weather forecasts.

In a world growing daily more sensitive to weather and climate, that would be enough.

But there are insights upon insights to come from this experiment. Already, as this issue of *NOAA* goes to press, a collection of preliminary GATE papers is coming off presses in Bracknell, England. Soviet scientists report apparent correlations between the intensification of the ITCZ and the convergence of cold fronts from higher latitudes, hinting at the hidden connection of atmospheric events across a hemisphere. NOAA's hurricane scientists describe what the long, slow ripples, or "waves" in the prevailing easterlies look like from the inside. Radiation data suggest that short-term variations in solar radiation received by the tropical atmosphere and ocean are greater than we thought. Cloud physicists from NOAA note that human cloudseeding would be incidental given the Sahara's natural inclination to overseed the air pouring off the African continent. OCEANOGRAPHER scientists see, in their monitoring of the Lomonosov Current, weather as well as climate in the ocean. And on. The building blocks of better understanding are in scientific kilns around the world.

The greatest excitement over GATE data, however, must be that of the scientists working on computer models capable of simulating the behavior of the ocean and atmosphere. GATE offers a unique opportunity. Although models and the increasingly powerful computers needed to run them have developed swiftly over the past decade, the global weather-observing system needed to match these models has not arrived. GATE provides the first long, uninterrupted set of adequately measured data.

Since last summer, investigators at NOAA's National Meteorological Center in Suitland, Md. have been developing the global data sets needed to provide a context for the data taken in GATE. For the first time scientists at NOAA's GFDL, Princeton, and elsewhere will be able to use GATE conditions as a starting point for their models, and run their predictions out against a future that is known in detail. They will be able to answer questions which, without the product of GATE, would have remained unanswerable: How well do your models perform? Are they as good as you think they are? Where are you on the road to long-range numerical predictive systems? How much weather observation—what level of detail—do these models really need?

Meteorology will not be the same, now that GATE has been made to happen.

What next?

The ability to monitor atmospheric and oceanic events closely, at many scales of time and space, as in BOMEX, as in GATE, has been demonstrated. A global observing system adequate to the subject of its observation—the world weather system—and models capable of simulating it are at hand. Later in the decade, the First GARP Global Experiment, FGGE, will take man's first series of globally simultaneous looks at world weather, with the timing and precision of last summer's observations in the tropical Atlantic. FGGE will be another milestone on the long, difficult road to understanding the atmosphere, climate, and weather—puzzles which have persisted from the beginning of time.

Photo: University of Rhode Island

Coastal Zone Management

Balancing Man's Demands of the Sea and Shore

BY WILLIAM J. BRENNAN

Photo: University of Rhode Island

Endangered Area—Nature and mankind have combined to threaten our coastal zone as illustrated by these Rhode Island sand dunes (above and opposite page). Prudent coastal zone management is required to enable the coastal zone to serve man's needs without being destroyed in the process.

The nation's coastal zone has been assailed by wind, wave and tide since time began. But never, from its beginnings, has it had an enemy like man.

Today, the coastline is under severe pressure. We need more energy, thus we bore through the coastal waters and into the bed of the sea in search of oil and gas. We need more food, thus we fish the coastal waters ever more intensely. We need more recreation, thus we flock to the beaches. We need an abundant water supply to process our goods, and we need landing places to bring ashore the resources of the sea, or to extract from the ocean those elements vital to our survival.

And as we move to meet these needs we place in jeopardy the very area which we expect to serve us so well.

In October, 1972, the Congress of the United States served notice that the time had come to protect this zone which embraces so much of the Nation's wealth and people. By a Senate vote of 68-0, and a House vote of 376-6, the Coastal Zone Management Act of 1972 came into being. Public Law 92-583 brings the Federal government and the states and their local subdivisions into partnership to solve some of the most pressing problems facing the nation today. The Federal government is charged with encouraging and assisting the states in exercising their responsibilities in the coastal zone through programs designed to achieve wise use of the land and water, "giving full consideration to ecological, cultural, historic and esthetic values, as well as to needs for economic development." The integrity of state programs are protected through a "Federal consistency clause," requiring all Federal agencies at work in the coastal zone to behave in a manner consistent with those programs.

Responsibility for administering the Act was given, through the Department of Commerce, to the National Oceanic and Atmospheric Administration largely on the basis that NOAA already had responsibility for the bulk of non-military interests in the nation's marine resources. Upon receiving this charge, NOAA created the Office of Coastal Environment, today redesignated the Office of Coastal Zone Management and headed by Robert W. Knecht.

OCZM has taken the Congressional direction of creating a new state-federal partnership in coastal zone management seriously indeed. Once it accomplished the traditional chore of translating legislative generalities into workable specifics, it began the process of interesting states in becoming members of the partnership, and then in assisting them in the program development process. States were attracted to the program not only because of the prospect of Federal grant assistance, but also because of the promise of a stronger hand in dealing with the Federal government in coastal issues.

But money came first; two-thirds matching grants to states for the development of their management programs and, once Federal approval is accomplished, additional two-thirds matching grants for implementation of the programs will become available. Within the first 18 months, 30 of the 34 eligible states and territories had applied for, and received, program development grants, totalling about $8 million in federal funds and $4 million in state money.

Twenty-four states, including Hawaii and Alaska, have coastlines on the Atlantic, the Pacific, or the Gulf of Mexico. In addition, Puerto Rico, Guam, American Samoa and the Virgin Islands clearly are coastal territories, for a total of 28 states and territories eligible

Photo: Dawn Smith

Photo: University of Rhode Island

Housing and Industry—Americans look to the coastal zone for industrial siting, port facilities and housing location. What such uses do to the coast's ability to support aquatic ecosystems must be considered in development of management programs. But, so too must the importance of these uses be weighed.

Photos: C. Parker, Oregon Coastal Conservation & Development Commission

Photos: C. Parker, Oregon Coastal Conservation & Development Commission

The People Decide—Inherent in the Coastal Zone Management Act is the concept that the people of an area must have a part in determining how the coastal zone is used. Public hearings are a vital part of the process states must go through in developing their CZM programs.

for participation in the coastal zone management program. Where, then, does the figure 34 come from? Recognizing that this country's "inland seas,"—the Great Lakes—accommodate some 15 percent of the nation's population and 25 percent of its industry. Congress included all eight states bordering the Great Lakes among those eligible, not merely those two which also have saltwater coastlines.

"Coastal zone management" is a pleasant enough phrase which generally wins ready acceptance. Most citizens today know that our fishing industry must sail farther from home shores for a satisfactory catch. Most are aware of the competition for acreage along the coastline, be it for privates homes or condominiums, nuclear power plant sites, recreation areas or conservation districts. Managing the competing demands upon both the lands and waters of the coastal zone sounds like an admirable idea, good for everyone. Who could oppose it?

Opposition was bound to emerge, as the concept of the Act and the plans of the varying states become more readily apparent. Effecting a balance among the demands means some interests will be called upon to make concessions; to compromise. And as the states set about creating their management programs, the problems of implementation become obvious. Even in those states which have been working on coastal area problems for years, understanding and acceptance of the goals often remain to be won.

Each state faces its own problems. Frequently there are common threads to be found; pollution, erosion, conflicting usage. Less universal problems are abundant, too, however; oil spills off California and the Gulf States, hurricane damage along the eastern seaboard, industrial development and overwhelming recreational demands in the more heavily-populated sections of the coast.

OCZM, interpreting the Act, has established criteria, outlining the process that each state's coastal zone management program should contain. But the Federal partner is not dictating to its allies how to reach the objectives. Recognizing the diversity of problems, the differences in public demands and needs from state to state, each state is given the greatest possible latitude within the confines of the Act itself. As a result, the preliminary planning by the states varies considerably.

Take Oregon, for example. Since 1913, when a little-noticed proposal by then Governor Oswald West slipped into being and declared all beaches along the Oregon coast as public highways no longer eligible for private purchase, the state has been involved in coastal zone management of a sort. As with so many other states, however, early coastal managers in Oregon felt management by regulation was the route to follow, and today there are more than 200 agencies—local, state and Federal—that have jurisdiction and/or legal interests in Oregon's coastal zone. As could be expected, a maze of jurisdictional disputes, conflicting policies and duplicated mandates has resulted.

The Oregon Coastal Conservation and Development Commission has been given the task of unknotting the administrative tangle, and the Coastal Zone Management Act of 1972 is its primary tool. Management by regulation has been cast aside in favor of management by objectives; the development of a guide to proper development techniques, not a finished blueprint for the Oregon coast. Coastal management, the commission reasoned, must be as responsive as the coastal zone is dynamic.

The commission proposed to fashion a series of policy guidelines to direct the future development and regulation of the coast. Policy implementation would actually be a continuing process of planning and management, working with a set of agreed-upon goals. Areas for development and areas for preservation would be earmarked. General conditions for use patterns would be set down—for example, no structure could create a geologic hazard without overriding social benefits. Each policy would pinpoint agencies responsible for permits, clearances and regulations. Federal and state concerns would be built into the policy guidelines, but specific land use decisions would be made at the local level where they generally have the most impact and significance. The guidelines would be the broad-brush strokes; local governments would add the detail and final coloring. New scientific information bearing on resource management could be continually incorporated into the system without completely revamping it.

Rhode Island claims to be putting the cart before the horse in its preliminary efforts, intentionally. Normally, planners would complete a comprehensive study and inventory of the coastal resources prior to formulating coastal policy which would preserve certain areas while steering development in others. But the nation's smallest state is doing it otherwise. There, a 17-member appointed coastal council with immediate and broad power to control marine resource use and development has been established and charged with regulating coastal development until a comprehensive management plan can be completed. The council has an extremely general policy statement by which permit applications may be measured. Meanwhile, an inventory is underway and as each part of the inventory is completed, management policy and regulations are adopted by the coastal council and added to the comprehensive plan. When completed the plan will contain an inventory.

One of the recognized problems with the Rhode Island approach is that of trying simultaneously to manage coastal development and to prepare a comprehensive management plan, with the resulting danger the plan is put together piecemeal and when completed the parts may not fit together as well as might be

Photo: University of Wisconsin

Recreation—The shoreline meets man's needs for solitude, swimming, sailing and other activities. Should these be sacrificed for other demands, such as housing, industrial development ? This is but one question facing those charged with developing coastal zone management programs in the United States.

Photo: University of Rhode Island

hoped. However, without the council's immediate intervention, various parts of the coastal environment might have been lost to developers, and protection accomplished for barrier beaches and salt marshes might not have occurred. Furthermore, the council has adopted management policy for oil transfer in Narragansett Bay and is soon expected to adopt policy for the coastal sand and gravel resource. The authority of the council is now widely recognized and its rapport with both state agencies and towns is steadily improving.

As in many other coastal states, a history of legislative action regulating use of coastal resources led to a fragmented and somewhat inefficient system in Texas. The majority of past and current research efforts are limited to a particular orientation—e.g., environmental, geological, biological, economic or political. Little effort had been made to coordinate the results of these studies and incorporate them into a comprehensive management scheme.

While Texas is considered by some not yet to need remedial action in its coastal zone, there is almost unanimous feeling that wise resource allocation decisions are called for. The state's coast is its most rapidly developing area, and as the population increases added pressures are placed upon the air, land, mineral and water resources of the coast. A number of large-scale industries vital to the economy of the state and nation—oil and petrochemicals, fishing, agriculture, and recreation—are sited on the coastline, many of these industries competing for the same resources, and this competition will grow more intense as resources become more scarce. Additionally, the Texas coast's geography causes many problems. Its low elevation makes it subject to flooding and damage from tropical storms. The bays are extremely shallow and ship channels must be dredged. And, the extraction of ground water has caused severe land subsidence in some areas.

In June, 1974, Texas initiated development of its coastal management program with a stated goal of achieving and maintaining a balance between economic development and environmental quality. The principal task, it was determined, was the designing of a flexible management process that would attain the desired goal while allowing for a maximum of local control of resource allocation decisions—a process that would support the private market system as well as the need for economic development.

The state's work program was designed to provide a basis for research through preliminary surveying of existing data and research relevant to management of the coast, surveying of the various governmental entities currently exercising authority in the coastal region, and surveying of coastal interest groups. The technical phase of the work plan consisted of three principal activities: 1) identification of expected demands upon coastal resources, 2) assessment of the capability of coastal resources to meet these demands, and 3) a study of the institutional mechanisms that could be employed to administer a process that would accommodate demands and capabilities.

Unlike Rhode Island, where perhaps the problems were more pressing, Texas is taking the more traditional planning approach; and

About the Office of Coastal Zone Management

The Office of Coastal Zone Management was created within the National Oceanic and Atmospheric Administration, Department of Commerce, to implement the Coastal Zone Management Act of 1972, Public Law 92-583.

Purpose of the Coastal Zone Management program is to encourage and assist states in developing their own coastal management programs, to coordinate state activities, and to safeguard the regional and national interests in the coastal zone. A state coastal zone management program is a plan for the control of land and water areas in the coastal zone as well as a method of implementing this plan. State programs are expected to achieve wise use of land and water resources of the coastal zone, giving full consideration to ecological, cultural, historic, and esthetic values, as well as to needs for economic development.

The Coastal Zone Management program awards matching grants to coastal states and territories in three categories: 1) two-thirds support of the cost of developing a management program; 2) two-thirds support of the cost of administering an approved management program; and 3) one-half support of the cost of acquiring, developing, and operating estuarine sanctuaries for research and educational purposes.

Once the Secretary of Commerce approves a state or territory program, all Federal activities in the coastal zone, or which may affect the coastal zone —including grants, loans, licenses, and permits—must be conducted in a manner consistent with the approved program.

Thirty states and four U. S. Territories with tidal coastlines or whose borders are on the Great Lakes are eligible to participate in the Coastal Zone Management program. To date, 29 states and one territory have been awarded program development grants. Several states are expected to submit applications for program administration grants within the next 9 to 12 months, and one state (Oregon) has been awarded an estuarine sanctuary grant.

About $8 million in Federal funds have thus far been awarded states and one territory in program development grants, and an additional $9 million is available for second year grants for program development assistance. Matching funds allocated by the participating states amounted to almost $4 million during the first year, indicative of their interest in the program.

The first estuarine sanctuary grant, awarded to the State of Oregon, amounted to approximately $823,000. Several other proposals for estuarine sanctuaries have been advanced, and grant applications are anticipated within the next several months.

The Office of Coastal Zone Management also administers the Marine Sanctuaries program, established as part of the Marine Protection, Research, and Sanctuaries Act of 1972 (Public Law 92-532). Purpose of this program is to preserve or restore marine areas for their conservation, recreational, ecological, or esthetic value. The first marine sanctuary nominated—the site of the wreckage of the *U.S.S. Monitor*—is now being processed for anticipated designation early in 1975.

this requires early establishment of criteria to help identify:

- natural areas with unique or fragile character and historic/cultural areas where any significant development would be likely to have unacceptable effects,
- areas especially needed for and suited to intense development in that they can support this development at acceptable levels of impact on the environment and upon present uses,
- areas where it is probable that certain uses would have an adverse impact on either the environment or present patterns of use.

The technical phase of the program is addressing, among others, the issues of economic development, urban population growth, water supply, waste management, residential and resort home development, and power plant siting.

The impact of the program upon the people of the Texas coastal region has been to make them aware of the state's concern about the future of the coast, to explain the nature of that concern, and to inform them that the General Land Office has been designated as the state agency to develop a coastal management program.

A fourth state well into its coastal zone planning is Wisconsin, one of the seven Great Lakes states in the program (as of this writing, Indiana—the eighth of the states with Great Lakes shorelines—had not evidenced interest in participating). Uses and demands of the Great Lakes coastal zone are similar to those of saltwater coasts; living space and recreation, industrial and commercial activities, waste disposal, food production, and natural preserves and special government uses. But there are differences, not only between the ocean and the lake coastlines, but between the coastlines along the lakes themselves.

Wisconsin has two coasts comprising a 620-mile coastal zone; one along Lake Superior where the coast is relatively pristine and undeveloped, the other along Lake Michigan, a megalopolis with its two urban poles at Green Bay and Milwaukee. Clearly, managing the state's total coastal zone involves a different set of assumptions for each lake, somewhat akin to the different needs inherent in managing the coasts of Maine and New Jersey, for instance.

In the matter of differences between salt and fresh water coastal management, Knecht says:

"The lake level problem, of course, is unique. The importance of commercial navigation has a direct tie to the maintenance of adequate lake levels. The winter ice problem is not faced in the same way by coastal communities on the oceans. The matter of power generation and shoreline erosion are larger problems here (in the Great Lakes) than in many places along the ocean coastline. So, in many senses, the Great Lakes truly present a unique set of coastal management problems."

In its first year in the CZM program Wisconsin is conducting resource inventories and user studies to identify major coastal zone issues, five of which were recognized early on: erosion, public access to use of the lakes, recreational pressures on the coastline, port-development, and power plant sitting.

Wisconsin has a long-standing tradition of citizen involvement at the local level, and the state's CZM planners are insuring maximum opportunity for the highest degree of public participation, as well as for plenty of intergovernmental interaction. Initially, a 26-member State Coastal Zone Coordinating and Advisory Council was appointed, including representatives of county, city and village governments, regional planning commissions, the University system and state agencies. The council's duties are to set program direction and advise the governor on coastal policy.

The council co-chairmen, one representing state interests and the other regional concerns, are appointing a second 26-member committee consisting of representatives of identifiable interest groups in the coastal zone, ranging from development to environmental groups.

Reaching the public to gain its understanding, its input and its support is the major undertaking during the initial year. State CZM planners are utilizing a wide range of techniques, from bumper stickers designed to arouse public curiosity of informational workshops and discussion sessions, radio, TV and print publicity, and direct mail folders.

Four states, with four different sets of problems and four varying approaches to solutions. Multiply by eight to recognize the complexity of the total coastal zone management problem on a national basis. No one can predict the future of coastal management with certainty, other than to forecast that many months of hard work lie ahead; months of attempting to pull conflicting interests into a comprehensive, rational, cooperative program that it is hoped will achieve the goal set by Congress: "to preserve, protect, develop, and where possible, to restore or enhance the resources of the nation's coastal zone for this and succeeding generations."

(This article was prepared with the cooperation and assistance of Bruce J. Cole of the University of Rhode Island, James A. Folts of Oregon State University, James J. Napoli of the University of Wisconsin, Robert Richards of the Texas Coastal and Marine Council, and Richard Rigby. Ed.)

Science seeks to fathom a strange climatic problem

El Niño

BY PATRICK HUGHES

El Niño. They call it The Child, because it traditonally begins around Christmastime.

But El Niño, a weather-related ocean change that visits the coast of Peru at irregular intervals, brings no joy. When it comes, millions of small fish called anchovy disappear, other fishes, birds, and marine mammals die, the Peruvian economy suffers a severe setback, and the cost of fishmeal and chickens rises sharply in the United States and other countries.

El Niño last visited the coast of Peru in 1972. Now there is speculation that it may return again early this year.

According to Jukka Kolhonen, an economist with NOAA's National Marine Fisheries Service, Peru's annual anchovy catch dropped from over 10 million metric tons in 1971, before El Niño, to 4.5 million tons in 1972 and 1.8 million in 1973. Because Peru is the world's leading producer of fishmeal used in chicken and livestock feed, this caused a drastic drop in fishmeal production. Due to the decline (and concurrent shortages of soybean meal, a possible substitute) the price of Peruvian fishmeal increased from an average of $163.30 a ton at East Coast U.S. ports before El Niño to $493.75 a ton by July 1973.

Prices of other kinds of fishmeal also rose. By the end of 1973, when no Peruvian fishmeal was available, prices of menhaden meal had risen to $537.50 a ton, three times its price before El Niño.

Because of high feed prices, the average annual cost to the U.S. farmer of raising chickens rose from about 14 cents a pound in 1972 to about 24 cents in 1973. The price freeze then in effect prevented the farmer from passing this increase on to the consumer, and forced a cutback in production which resulted in the drowning of thousands of baby chicks.

Prices of fishmeal fell sharply in the first half of 1974, but weather damage to U.S. soybean and corn crops last summer reversed the downward trend and caused the price of feeds, including fishmeal, to begin rising again, despite a partial recovery in Peruvian fishmeal production.

Thus, a climatic fluctuation changed ocean conditions off Peru, resulting in higher costs for poultry and livestock raisers and, eventually, higher food prices for the consumer. Moreover, these effects were reinforced and extended by another climatic fluctuation which reduced U.S. grain crop yields some 18 months later.

The Humboldt or Peru Current which flows northward along the West Coast of South America teems with life. This is due primarily to the vigorous, nearshore upwelling of colder, nutrient-rich subsurface water produced by prevailing winds and the rotation of the earth. Microscopic plants and animals called plankton thrive in the cold, rich water and, in turn, provide abundant food for fishes, particularly the anchovy, which throng the current and provide Peru with the greatest signle-species fishery in the world.

When El Niño visits the coastal waters of Peru, the upwelling slackens or stops, surface waters become warmer, and salinity decreases. The results can be disastrous for marine and bird life, as well as for the Peruvian fishery industry. Nutrients are quickly exhausted, then the plankton, followed by the dispersal of the anchovy and the death or dispersal of millions of sea birds that feed on them.

Other fishes and marine mammals also die, and rotting fish, mammal, and bird carcasses can cover local beaches and clog nearby coastal waters, while the sea is often colorful, but toxic with plankton "blooms". Hydrogen sulfide released by decomposition blackens the hulls of ships and boats in the area, a phenomenon called the "Callao Painter," because it often occurs off the Peruvian port of Callao.

El Niño sometimes brings torrential rains and violent windstorms to coastal areas of northern Peru, causing floods and heavy soil erosion. Normally, despite its tropical latitudes, the Peru coastline is a cool, misty desert. Prevailing winds blow from the south and southeast, pushing the Peru Current northward, while the effect of the earth's rotation (Coriolis force) tends to deflect the surface water westward. As the surface layer is skimmed off, colder water rises to replace it. This "upwelling" takes place relatively close to shore, resulting in water temperatures 2–3 degrees Centigrade (C) cooler than those of the main current. The cooler, inshore water is sometimes called the "Peru Coastal Current," in contrast to the "Peru Oceanic Current," and is the home of the anchovy. Before the El Niño of 1972, this relatively tiny thread of water produced 22 percent of all the fish caught in the world.

Dr. Clarence Idyll, a NOAA marine biologist and an expert on the Peruvian anchovy, estimates that at the height of their population, the Peruvian anchovy population's bulk probably totaled 15 to 20 million metric tons. During a normal Peruvian summer, fishermen working the narrow, shallow Coastal Current often caught anchovy 100 tons at a time.

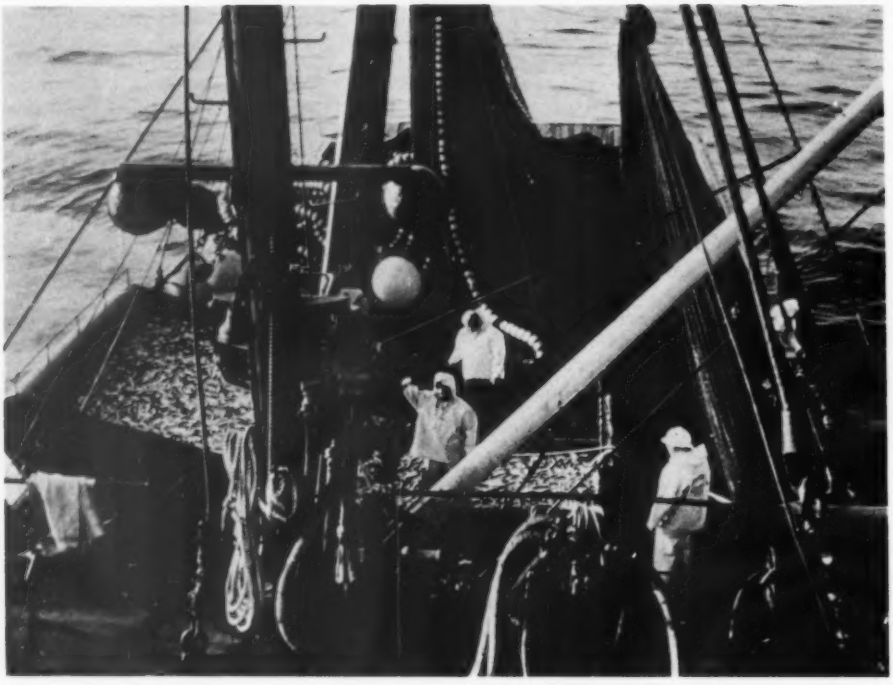
In recent years, thanks to the coastal-hugging, surface-swimming anchovy, Peru had become the world's leading fish-producing nation. Until 1972, it was catching anchovy at a rate of more than 10 million metric tons a year, twice the tonnage of the combined all-species catch of all the nations of North and Central America. Nearly a third of Peru's foreign exchange came from fishery products export, while industry taxes and jobs were major elements in Peru's domestic economy.

Man is not the only fisher of anchovy. They are also preyed upon by great flocks of seabirds, which feed almost exclusively on these tiny fish. The anchovy is thus the raw material for bird guano, perhaps the most effective natural fertilizer known to man. Thanks to the anchovy, Peru's coastal waters normally are home to possibly the largest population of seabirds in the world, whose peak number has been estimated as high as 30 million birds.

When the anchovy disappear during an El Niño, adult birds abandon their nests and young, which die in great numbers. It has been estimated that the severe El Niño of 1957 reduced the bird population from 27 to 6 million.

According to Dr. Warren Wooster of the University of Miami, an authority on the subject, an El Niño occurs when the seasonal slackening of the Southeast Trade Winds during the Southern Hemisphere's summer is much more pronounced than usual,

Boats of the Peruvian anchovy fleet tied up at the port of Callao. Recent shortages of the small fish have reduced the number of vessels in use. (Photo by C. P. Idyll.)



Purse seine vessels such as these fish the cold waters off Peru's Pacific coast where anchovy population is significantly reduced during occurrences of the El Niño effect. The past abundance of anchovies here has made Peru a vital exporter of high protein fish meal, shown bagged for shipping at right. (Photos by C. P. Idyll.)

sharply reducing the wind stress on nearshore surface waters. As a result, upwelling is greatly reduced or ceases, tropical water from the north penetrates further south than usual, and a thin layer of warm, high-salinity ocean water comes within 10 miles or so of Peru's central and southern coast. Once upwelling has lessened or stopped, higher surface water temperatures result from solar heating and the coastal drift of open ocean surface waters toward Peru. In recent years there appear to have been major El Niños in 1957, 1965, and 1972, and minor ones in 1951, 1953, and 1969.

Most scientists agree that El Niño is a local expression of much larger atmosphere/ocean changes. The cause of the El Niño effect has not yet been isolated, but it seems to be related to non-seasonal flutuations of the global atmosphere circulation. Dr. Jerome Namias, for example, formerly of NOAA's National Weather Service and now a research scientist at Scripps Institution of Oceanography, has found correlations between changes in the mean air flow 2 miles above the earth and the visit of El Niño to the Peruvian coast some 5 months later.

Last October, at an El Niño Symposium held at Lake Arrowhead, California, Professor J. Bjerknes of the University of California at Los Angeles used global wind analyses derived from satellite cloud pictures over a four-year period to show that there were marked differences in atmospheric circulation patterns over vast areas of the world during the El Niño year of 1972–73, as compared to the 3 non-El Niño years.

At the same meeting, Dr. Klaus Wyrtki of the University of Hawaii challenged the traditional association of El Niño with an unusual weakening of the southeast Trade Winds. Rather, he theorized that in some years and for long periods these winds blow much stronger than usual, piling up water and raising sea level in the western Pacific. When they do slacken, the water flows back to the eastern Pacific. Since coastal upwelling is a shallow phenomenon restricted to depths of 30–50 meters, all that is then brought to the surface is the overlying, warm water from the west. Eventually, however, mean sea level returns to normal, and colder water is once more within range of the 30–50 meter upwelling process.

Whatever the cause, meteorologists and oceanographers are searching for key interactions between atmosphere and ocean that might make possible the prediction of El Niño's visits. Based on his studies, for example, Dr. William H. Quinn of Oregon State University thinks there could be a weak El Niño this year or next, and at press time, the University of Hawaii had submitted a proposal to the National Science Foundation to establish an El Niño watch to monitor developments.

The El Niño of 1972 was one of the most severe ever recorded. Surface water temperatures in the Coastal Current rose from 22 degrees C. to over 30 degrees in February,

then stayed abnormally high through March 1973. The anchovy catch dropped to almost zero from early 1972 until the end of 1973, when the Peruvian Government allowed fishing to begin again on an experimental basis, limiting the 1974 catch to 5 million tons.

The 1972 disappearance of anchovy brought hardship and unemployment to Peru's fishmeal industry. The Government nationalized the industry in May 1973, reducing the number of fishing boats from 1,500 to 800, the number of fishermen from 25,000 to 12,000, and the number of fishmeal packing plants from about 100 to 50. By this reorganization, the Peruvian Government hopes to enforce conservation measures, cut production costs and, through more efficient operations, increase the yield of fishmeal per catch for export.

The United States, West Germany, the United Kingdom, and the Netherlands are the major importers of fishemeal. About two thirds of the fishmeal used in the United States is used in broiler (chicken) feed. In Europe, it also is used in pig and cattle feed.

Fishmeal is an important protein source for poultry and livestock feeds. It is richer in protein than soybean meal, its most important competitor, and contains amino acids not found in vegetable protein. Fishmeal also contains a yet-unknown growth factor which makes its use in feed formulas particularly desirable. Broiler feed normally contains from 2 to 10 percent fishmeal; quantities higher than 10 percent tend to give the chicken a fishy taste.

Peru's fishmeal production for 1974 is expected to total about half of the 1967–71 average, and conservation measures probably will hold future production below the old levels. This will mean higher proportions of grain substitutes in feed formulas, grains badly needed to feed people at a time when world grain surpluses have dwindled to the vanishing point, and potential shortages await only unfavorable weather in one or more major grain-producing regions of the world (see "Climate: A Key to the World's Food Supply," in the October 1974 issue of *NOAA*).

NOAA's new Center for Climatic and Environmental Assessment (CCEA) was established by the Environmental Data Service to assess climatic and other environmental fluctuations and, where possible, provide early evaluations of their probable impact. Better understanding of the largescale air/sea interactions responsibie for such fluctuations should come with the improved global monitoring of ocean and atmosphere made possible by environmental satellites. This understanding could eventually provide the basis for reliable prediction of such events on a relatively long-term basis, giving time to prepare for their occurrence.

NOAA's Undersea Surveyors

BY RAYMOND S. WHITE, JR.*

The scene below was eerie and tragic.

There, upside down in about 25 feet of water lay the missing Coast Guard Albatross aircraft with only the wings, motors, and part of the fuselage intact. Parachutes from a large flare aboard the plane floated in the current. Nearby, equipment of all sorts littered the area. One landing gear swung aimlessly from side to side.

I was one of the scuba team from NOAA's twin wire drag ships RUDE and HECK responding to a Coast Guard request for assistance just hours after the seaplane crashed into the ocean while on a sea-air rescue mission involving a lost fisherman near Port Aransas, Texas, in September 1973.

While most of our work is routine (if any job involving scuba diving can be called routine), sometimes it gets very tense. Our job is to dive into the sea and determine whether a wreck or other obstruction poses a hazard to ships that ply the trade routes to and from America's ports. If so, we obtain the needed data to be entered on nautical charts issued by NOAA's National Ocean Survey for the Nation's mariners.

This time, however, our job was far from routine.

On arrival at the general area of the crash, Commander Leonard Pickens, skipper of the NOAA ships, ordered a wire drag sweep of the site to pinpoint the wreck. During this operation the two sister ships drag a one-quarter-inch steel wire between them, sometimes at distances up to two miles, to locate underwater obstructions. The wire is suspended under water from surface buoys at depths down to 90 feet. As the wire catches on an obstruction, it becomes taut and the surface buoys form a "V." The exact location of the obstruction and the water's depth above it is then determined. If necessary, scuba divers examine it.

In the case of the missing aircraft, the wire drag located the wreckage within a few hours and two teams of divers prepared to investigate to make certain it was the missing plane. Ensign Kenneth Van Train and Ordinary Seaman Gregory Kissel comprised the first team. Within half an hour they returned to the surface and reported that the missing aircraft was below. Lieutenant (junior grade) Harold Arnold and I then went down to take a closer look at the wreckage and try to locate the missing crewmen.

A major objective of NOAA's Heck *is to assist in locating underwater obstructions that pose a hazard to ships plying the trade routes to and from America's ports.*

Arnold collected two clues to the plane's fate from gaping holes in the aircraft's body: a burned flotation pack and parachute harness. Also we noted blackened areas around a rear door. The terrible story almost told itself. Ironically, one of the large, million candlepower illumination flares used to provide light during nighttime lifesaving rescue missions had apparently ignited on board, causing the plane to lose control and crash into the sea.

The bodies of five members of the crew lay buried in the wreckage of the fuselage and were recovered when it was raised. The pilot was found in the broken-off tail section some distance away.

This was an unusually grim assignment. Most of NOAA diving operations involve the day-by-day task of determining the "least depth" or distance from the highest point of the submerged object to the surface of the water. This operation is extremely important for safe navigation, especially in areas such as ship channels and anchorages.

An obstruction, even a few feet from the bottom, is a potential threat to any deep draft vessel in the vicinity. In the case of the modern supertanker, the resultant oil spillage after an encounter with such a hazard could have disastrous effects on the local marine environment.

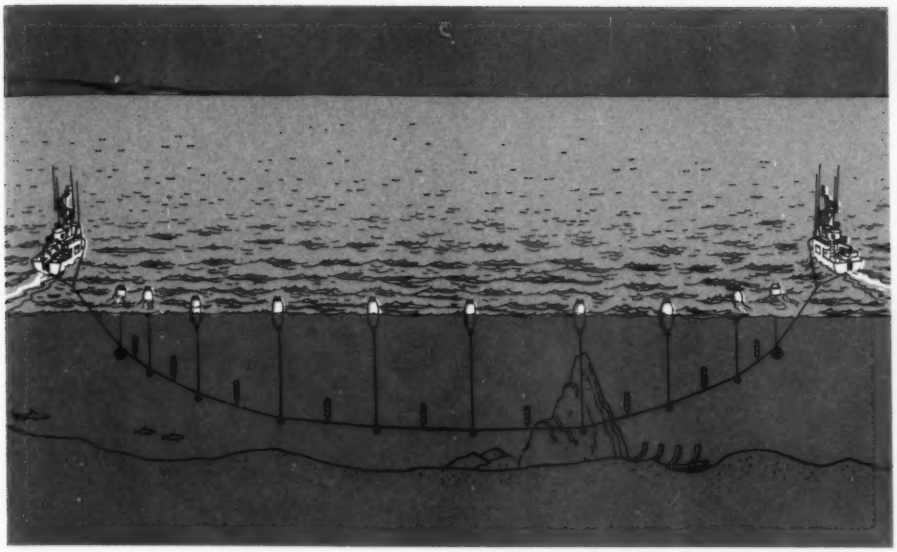
Determining the least depth is relatively simple. Off Mobile, Alabama, the wreck of the sunken trawler was found. Her bow revealed the name "Gracie L." NOAA Ensign Thomas Bergner and I ascended to the masthead, her highest point, and there took simultaneous depth gauge readings, the current proving too strong for a leadline or Bryson gauge. Those least depth data eventually appear on NOAA's nautical charts to warn oncoming ships of the hidden danger.

How does one become a scuba diver for this important NOAA mission?

Candidates for diver status travel each December at the end of the NOS "field season" to Miami, Fla., for an intensive two week course in Self Contained Breathing Apparatus (SCUBA). This is the only diving method employed aboard the wire drag ships.

After a thorough classroom program of

**Raymond S. White, Jr. is a Seaman Surveyor on the NOAA Ships* RUDE *and* HECK.



A submerged wire, suspended between the two NOAA ships, the Rude *and the* Heck, *is used to snag underwater objects which are investigated by a team of at least two divers.*

Seaman Gregory Kissel helps Seaman George Moore in his preparation for a dive in the cold waters of the Chesapeake Bay.

On the murky bottom of the Gulf, Ensign Tom Bergner must use heavy gloves to protect his hands from steel barbs of the buoy wire.

diving fundamentals ranging from underwater physiology to the construction of scuba regulations, the candidate is tested on all facets of diving theory. On the practical side, he must make night dives and shallow water dives and be able to shed his gear and complete "free ascents" to the surface. Finally, the novice makes a descent to at least 130 feet. He is now classified as a NOAA operational diver and is sent to his ship, ready to assume his underwater duties for the following field season.

A RUDE/HECK diver may be called upon to dive any time during the workday, whenever the wire drag sweep has found its mark, known in wire drag parlance as "the hang." A hang is simply the submerged wire encountering an object and causing the RUDE and HECK to come to a stop.

As the wire drag draws into a tight V shape, with the object to be investigated at the apex, the two vessels heave to and maintain their position while a team of at least two divers prepares for the descent. After dressing in full wetsuits if winter conditions prevail (the wetsuits are discarded in summer), the team is carried to the apex of the drag by a waiting launch.

The launch is secured to one of the drag buoys near the hang and final preparations are made for the dive. All equipment is checked and various devices are prepared to measure the water's depth. Depending on conditions, three types of depth indicators are available. The first and least complicated is the leadline, graduated in feet. Next is the wrist depth gauge, an important companion to the diver who relishes his safety. Third, if conditions permit, the "Bryson-gauge" is employed.

This is a precision tool developed by NOAA Lieutenant A. Y. Bryson, formerly stationed aboard the RUDE and HECK. This instrument is fed from compressed air tanks aboard the launch. Since air is under a different pressure according to depth, a direct readout of this pressure is taken at the surface. Later, this information is interpolated into an actual depth in feet. Because of the many feet of air hose which must be carried below, the Bryson gauge is limited to mild sea conditions and current, as is the leadline. Even with these limitations, the Bryson gauge is highly accurate and furnishes precise depth information.

While operations up to this point have been more or less routine, there is nothing ordinary about the diver's voyage down the wire drag toward the hidden obstruction. What will it be? Perhaps it is a long-sunken vessel with the remnants of her cargo still aboard. Several times in the past the RUDE and HECK have found such prizes. On one occasion, in Delaware Bay, the wire drag turned up a 19th Century hulk, a merchantman laden with a cargo of British china. There they laid on the bottom, still neatly piled amid the wreckage of the once proud ship, thousands of pieces of crockery of varying types and sizes.

On another occasion, the RUDE and HECK discovered the wreck of an armed sailing vessel off Lynnhaven Inlet in Chesapeake Bay. One of her cannon, manufactured in America during the War of 1812, is now displayed in front of the main building at NOAA's Atlantic Marine Center in Norfolk, Va., home port for the two wire drag vessels.

Five years ago, the RUDE and HECK located the wrecks of what are believed to be Confederate blockage runners of the Civil War. The more than a century-old hulls, possibly as many as five, were found off the harbor entrance to Charleston, S.C. All were apparently sunk by Union forces as they sought to slip into the blockaded harbor.

A year earlier, the RUDE and HECK conducted a search off Charleston for a World War II German submarine, variously reported seen in the area from time to time. The submarine could not be located despite persistent reports in Charleston that it had been scuttled by its crew after it became disabled and could not submerge. One of the submarine's captured launches was said to contain empty American-made milk containers and theatre stubs of a Charleston theatre, leading to speculation that the German crew took shore leave, undetected by the people with whom they mingled.

Diving aboard the RUDE and HECK thus has its moments both mundane and unexpected. While most dives are quite ordinary, divers are always prepared for the unexpected.

This is part of the nature of diving—and, in a larger sense, the nature of NOAA's oceanic and atmospheric mission—to get below the surface and attempt to see what is normally invisible. In diving as in science, sometimes it's a shock—always a fascination.

A century-old paradox

Noctilucent Clouds

BY JOAN VANDIVER FRISCH

With a roar heard 3,000 miles away, a rumbling volcano on remote Krakatoa Island between Sumatra and Java exploded in 1883, belching approximately four cubic miles of earth into the air, and creating spectacular sunsets for years to come. Scientists around the world began watching the heavens more closely, intrigued by the vividness of the dust-laden skies at twilight. Halfway around the world a German scientist, T. W. Backhouse, had been routinely scanning the reddened skies when he noticed an unusual phenomenon—the existence of some strikingly brilliant clouds—two years after the volcanic eruption.

Since their discovery nearly a century ago, more than twelve hundred displays of what came to be called "noctilucent clouds" have been reported by atmospheric scientists. And yet these mysterious "Leuchtende Nachtwolken" also posed a paradox to their observers. Clouds are by definition visible water in the atmosphere. How, then, could noctilucent clouds form in the almost waterless region of the high upper atmosphere? Were they true clouds or iridescent bands of cosmic dust? The mystery has persisted.

Now Dr. George C. Reid, a physicist with NOAA's Environmental Research Laboratories, has developed a possible explanation for this geophysical puzzle. By mathematically modelling cloud particles that could exist in the upper mesosphere—the coldest and dryest region of the atmosphere—the Aeronomy laboratory scientist has simulated the processes that could reasonably lead to the formation of noctilucent clouds.

According to Reid, noctilucent clouds differ from more familiar types in several major ways. Although they occur very sporadically in large sheets or small patches resembling cirrus or cirrostratus clouds, the high clouds of the troposphere, noctilucent clouds occur at much greater altitudes at the mesopause, nearly 50 miles (80 kilometers) above the earth.

As their name implies, the "twilight" clouds are seen only against the background of a dark sky while they are still illuminated by the sun, hidden well below the horizon. All other cloud types are most visible during daylight. Noctilucent clouds' bluish-white wisps are seen most often during the summer months for periods of a few minutes to more than five hours, usually in latitudes above 45 degrees in both hemispheres—Canada, Alaska, the Scandinavin countries, Chile, and the Soviet Union. In contrast, other cloud types are seen at all latitudes around the world.

Despite the scientific interest they have sparked, only a few sightings of noctilucent clouds had been reported from North America prior to the summer of 1962, while hundreds of observations had been made in Europe and the Soviet Union. Atmospheric scientists began asking whether—for some unknown meteorological reason—the unusual clouds did not occur over North America as often as elsewhere. To pursue this question and improve the general knowledge of the mysterious clouds, Dr. Benson Fogle, then of the University of Alaska's Geophysical Institute at College, Alaska, initiated a study of noctilucent clouds over North America in 1962 under a National Science Foundation grant.

The data obtained by the ensuing network of observing stations set up in cooperation with NOAA's National Weather Service, then U.S. Federal Aviation Administration, and the Canadian Meteorological Service proved that the high-altitude clouds occur as frequently over North America as over Europe and the Soviet Union, and that the previous scarcity of observations was probably due to lack of interested and informed observers.

Reid became intrigued by the noctilucent cloud mystery after learning of some interesting measurements made by the National Aeronautics and Space Administration's OGO-6 satellite. Equipped with a horizon-scanning, two-color photometer—an instrument which measures the intensity of light—the spacecraft was launched into a polar orbit, varying its path between 250 miles (400 kilometers) and 688 miles (1,100 kilometers) from the earth.

Although the satellite itself only reached a latitude of 82 degrees as it streaked toward the north pole, the field of view from the photometer 47 miles (75 kilometers) above the earth at its closest approach was much farther north, giving atmospheric scientists a much better view of the polar cloud layer than any previous research instrument.

Drs. T. M. Donahue and B. Guenther, two physicists at the University of Pittsburgh, and J. E. Blamont at the University of Paris, France, concluded that the noctilucent clouds observed occasionally during summer twilights at high latitudes are mere ragged extensions to lower latitudes of a persistent phenomenon that develops over the geographic north pole during summer. During the month of June in 1970, the polar cloud's rate of occurrence increased; so did the frequency of observing noctilucent cloud displays at twilight in the same latitude region. The Pittsburgh team found that the thin intense scattering layers developed over the pole about 15 days before the summer solstice on June 21, and are a permanent feature of the summer atmosphere at 53 miles (85 kilometers) above the earth.

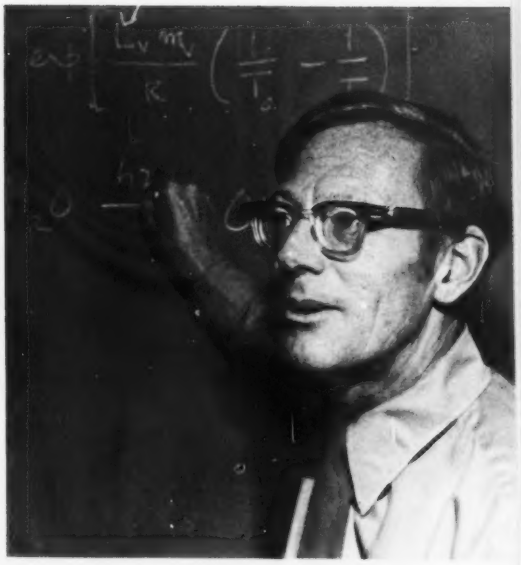
"Donahue and his colleagues suggest that noctilucent clouds are merely weak sporadic manifestations of these persistent polar layers, which presumably cannot themselves be easily detected because of unfavorable solar lighting conditions," Reid says.

To test their hypothesis, the Aeronomy Laboratory scientist has developed a simplified mathematical model of an ice cloud whose boundary conditions are similar to those estimated from the satellite data. Reid devised the hypothetical ice cloud model, assuming eddy diffusion—circulating currents of air—to be the only mechanism for transporting water vapor upward, and that cloud particles grow from initial sizes comparable with dimensions of electrically charged particles or ions.

The NOAA scientist based his mathematical model on a suggestion by Swedish physicist Georg Witt that positive ions, rather than meteoric dust, would provide nuclei for particle growth since no dust particles have been detected by rocket sampling experiments of noctilucent clouds. Previously scientists had speculated that volcanic or cosmic dust particles may have supplied the nuclei for ice particle growth, similar to other types of cloud-forming nuclei.

Reid explains his theory this way. "Since cloud particles grow as they fall, the numerical computations start at an altitude well above the cloud—56 miles [90 kilometers]—where little water vapor exists. When the simulated water-vapor pressure first reaches the saturation value, causing condensation to occur, the hypothetical cloud forms."

Noctilucent clouds (top), visible only after sundown, exist where other clouds do not. Although present during daylight they cannot be seen if the sun is above the horizon. These clouds (center) often appear about midnight at latitudes north of 45 degrees. They are shown (bottom) in a time lapse motion picture taken high above the Yukon Territory.



Dr. George C. Reid of ERL's Aeronomy Laboratory explains calculations for noctilucent cloud model.

In the model, cloud-top level is reached at about 53 miles (85 kilometers) altitude. Below this level, the ice particles grow as they fall through the cloud until they reach the 51 mile (82 kilometer) level, at which point they begin to lose water by evaporation. The cloud base is reached only a few hundred meters below this, when the particles have lost enough water vapor to begin their upward climb again by eddy diffusion—a random process similar to hitchhiking a free ride on a wayward wind—initiating the cycle all over again within the "cold trap".

"Until now scientists have assumed that the individual particles in the noctilucent clouds were spheres, implying either that there is much more water vapor in the mesosphere—the atmospheric shell extending from the top of the stratosphere to the mesopause—than current estimates suggest, or that a persistent upwelling of air exists over the summer polar regions," Reid says. "A more likely possibility is that the cloud particles are nonspherical."

Reid's study shows that either needle-shaped or disc-shaped ice particles of certain dimensions could grow within noctilucent clouds without violating mesospheric water-vapor content theories or assuming an upward movement of the atmospheric region as a whole. His hypothetical cloud model gives a plausible explanation for the existence of noctilucent clouds by demonstrating that nonspherical ice particles can grow near the mesopause, despite the near absence of water vapor, to form a layer 2 to 2½ miles (3 to 4 kilometers) thick—a measurement which agrees with the thin polar cloud layer observed by the OGO–6 satellite. As a result, atmospheric scientists may be one step closer to solving the century-old mystery of the elusive and beautiful noctilucent clouds.

Sea Grant, NMFS support a hardy band of experts

They Serve The Fishermen

BY MIKE BROWN*

In a few hours it would be Christmas Eve on the coast of Maine. Spits of cold snow driven on a colder northeast wind begin to gather on the windshields of the last of the scallop boats heading for the harbor at Jonesport. The scallopers, hardy fishermen, tired fishermen, would soon be home for a steaming scallop stew and the comfort of their families.

All but one. On his last tow, his drag wire parted leaving a $500 piece of fishing gear on the bottom. He tried to grapple the drag and although his marker was surely near the lost gear, the drag eluded the small grappling hook.

The fisherman turned for home—and a phone call.

For Bill Sheldon, a fisheries extention agent with the Maine Department of Marine Resources, Christmas Eve was a time to be home. But five minutes after getting the fisherman's call, Bill in his battered pickup truck loaded with scuba gear was headed for Jonesport.

It was dark when the two men returned home that night. Very dark. Santa Claus was halfway through his rounds. But one Jonesport scalloper had his $500 drag safely aboard—and would be ready to fish with the rest of the boats the day after Christmas.

This service is typical of the friendly, respectful, eyeball-to-eyeball association that Maine's seven fisheries extension agents have with the downeast fishermen.

All have specialties—big boat, small boat, mechanic, engineer, writer—but they all have sea savvy and a respect for the intelligence of the fishermen who ply the coast of Maine for nearly 25 different species of marine life. The area is longer than the combined coastlines of the states of Washington, Oregon and California—some 3,500 miles, and a fishermen in about every nook and cranny of that rugged shore.

Maine's Fisheries Extension Service started with the former Department of Sea and Shore Fisheries in 1966. It had one full time person.

Today, on $75,000 in NOAA Sea Grant funds—and additional money from NMFS through the PL 88-309 program—it fields seven men and two boats. It takes a lot of improvisation and 60-hour work weeks.

Scallop dredges constructed by Department of Marine Resources extension agents (top). These are among the types of dredges fished on extension service vessels. At right, extension agents and members of a Sea Grant site evaluation team examine various kinds of fish caught in experimental fish trap. (Photo by Maine Dept. of Marine Resources.)

The extension agents need and solicit the help of the other divisions of the Department such as research and enforcement wardens. Cooperatively, there have been many accomplishments and benefits to the Maine fishing industry.

For example, Maine is blessed with elvers, small eels that migrate from the salt to fresh water as sure as the sun and moon phases. One extension agent, among his other duties, has become a specialist with this resource. Traveling to Canada to observe and exchange ideas with that country on elver research, the agent began his own survey in Maine. A market interest developed in Europe and Asia and the agent, with the cooperation of area biologists, surveyed most of the state. A preliminary booklet on the Maine elvers was published and a more comprehensive offering is in the works.

Another kind of activity began when Maine fishermen came to the Department for help because the northern Maine shrimp catch was declining. The fishermen were concerned that without any management of the shrimp resource there soon would be none.

Northern shrimp are not exclusive to Maine. The states of New Hampshire and Massachusetts send many of their fishermen into the Gulf of Maine for the small delicacy.

Negotiation started and soon a tri-state project, aided by the National Marine Fisheries Service, came into being. A Department of Marine Resources extension agent was named field party chief. Under his direction, experimental nets were made and fished aboard a chartered vessel out of Gloucester for a six-month period. Shrimp samples taken from tows of various size nets were forwarded to a NMFS lab and data slowly compiled.

The result was that on October 2, 1972, at Savannah, Georgia, the commissioners of the Atlantic States Marine Fisheries Commission promulgated a new shrimp net mesh regulation based upon the extension-supervised survey work. It was a regional answer to a regional problem initiated by the states and endorsed by the federal government.

Of course, Maine's tremendously elongated coastline has its pros and cons. There is diversity not only of marine species, but also of opinions on how to catch them. Provincialism is not old fashioned in Maine. This begets other problems, mainly, that the fishermen act and react as individuals thus denying themselves the benefits of togetherness.

About three years ago a group of fishermen from a small village approached a Department of Marine Resources extension agent about some help in organizing a coop-

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Mike Brown is with the Fisheries Extension Service, Maine Department of Marine Resources

Photo: State of Maine Dept. of Marine Resources

erative. They were long on enthusiasm but short on know-how. They were confused about the environmental laws, the federal requirements and the legal ramifications. And to be candid, they were somewhat apprehensive about the reaction by the state's large processors who had traditionally bought the fishermen's catch at the processor's prices.

The agent agreed to help. He spent long nights at organizational meetings. There were longer delays caused by traveling from one state agency to another in search of answers and it became clear why co-ops were practically non-existent. Fishermen, to make a living, have to be on the water. They can't tramp the halls of bureaucracy and still fill the sugar bowl.

The Department of Marine Resources agent did finally succeed in organizing a legal co-op. He even did a preliminary engineering sketch for the dock.

Success is a natural breeder, and today not only are there several new fishermen co-ops in Maine, but an overall state co-op gathering the many into one large voice of purchasing and selling power.

One of the benefits from the close association the agents have with fishermen is the feedback on day-to-day problems. The non-academic, or practical, approach to these situations is important. Two examples will illustrate:

Lobster pound owners have to feed their lobsters. But the fish used for feed are usually large, resulting in lobsters fighting over their feed and causing mortalities. Also, round fish fill with gas and float on top of water.

The extension agent engineer accepted a request for a "fish chopper." Cooperating with the state university's engineering department, a compact, inexpensive chopper was designed and built and several are now in use by happy lobster pound owners in Maine.

But then came the clam grader. Clams in Maine are almost entirely hand dug. Taken to dealers, they are graded into steamers, fryers and chowders. And again, all by hand. Obviously a mechanical clam grader was needed.

A design was initiated by the Extension Service and in a few weeks the test run was made. It was a complete disaster. Luckily, the Extension Service paid for the clams because it broke more than it graded. Clams crunched all over the place. Four revisions (and several bushels of clams) later the Extension Service announced to the clam industry that if it wanted a better mouse trap, the Extension Service obviously wasn't the one to build it.

But the point is, the admitted frankness about the defeat didn't hurt extension's credibility.

Other engineering by extension has been highly successful. Designs of hydraulic scallop and clam dredges have been published for the industry.

The Department of Marine Resources Extension Service builds and fishes almost all of its experimental gear. Some examples are floating fish traps for lobster bait evaluation, scallop and clam dredges, trawls, onboard machinery—and so on.

Inshore scalloping is a big business in the state. When lobsters stop crawling the fishermen convert to scallops. The traditional gear is crude—a relatively small piece of gear towed over suspected scallop grounds in hopes that the course, speed and depth are correct.

An extension team decided to find out just how efficient a scallop dredge was. A conventional dredge was fished in a conventional way but with an extension scuba diver riding the headbail. As expected, the diver's observation confirmed that scallop dredges are exceedingly inefficient on most kinds of bottom.

This coming season, extension experiments will begin on a hydraulic dredge for scallops.

It takes close communication for agents to work effectively for fishermen, and someone has commented that the only group that has more meetings than fishermen in Maine are the Grangers. Extension agents are routinely present at these small gatherings. Sometimes only a half dozen fishermen will meet to discuss a local question. Invariably, the

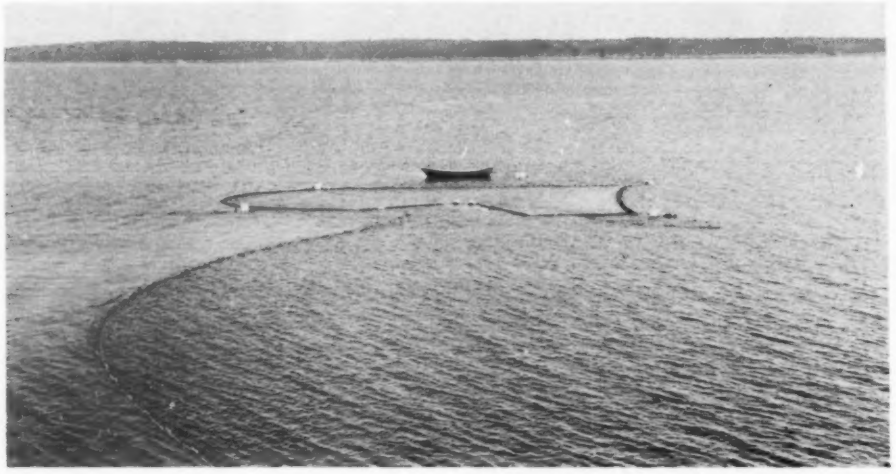
agent is asked to become the liaison with the bureaucracy.

When money is available, the Extension Service will bring in professionals in such areas as hydraulics and hold a series of schools along the coast. Maine fishermen must be carpenters, mechanics and electricians to maintain their gear in fishing readiness. And as gear becomes more sophisticated, so does the maintenance.

Maine's fishing industry, probably not unlike the rest of the country, always seems to be in a crisis. The Department of Marine Resources extension agents are in the forefront of these situations. The industry expects action and answers and the agents must offer both.

ITEM: The red tide hits the coast and puts 4,000 clam diggers out of work. The agents must report the research criteria which closed the flats—and in an understandable language. The agents must gather any information available on either state or federal compensation and report this quickly to the out-of-work diggers.

ITEM: A disease called red tail invades the lobster holding pounds, causing critical numbers of mortalities. Extension divers inspect these pounds on request, relaying their observations to the research divisions, which in turn makes recommendations for evacuation of all lobsters, or some other chemical remedy. The quick action could mean the difference between a $100,000 loss or profit.



Photos: State of Maine Dept. of Marine Resources

Experimental fish trap built and operated by Department of Marine Resources extension agents to determine feasibility of catching lobster bait with this type of gear (top). A Canadian hydraulic clam dredge is demonstrated (above) for clam diggers during snow storm, a "normal" working condition in Maine. (Photos by Dept. of Marine Resources.)

ITEM: The fuel crisis causes the tie-up of boats. No diesel fuel is available, report the fishermen. An extension agent starts the inquiry on the shortage. Is it contrived or real? The answers come from the supplier, the dealer, the state allocation office. Usually the inquiries are sufficient and the oil is soon dispatched to the port in need.

ITEM: The Maine fishermen report they need help with the Internal Revenue Service. An extension agent meets with the IRS personnel and meetings are scheduled along the coast so that positions on both sides of the fence are ventilated. The problems may not disappear but dialogue is established.

ITEM: The state legislature is in session and a hundred marine oriented laws are proposed. An extension agent attends the hearings, watches the progress, assesses the chances of passage and reports to the Department so that appropriate advice can be given to the industry.

The Maine Department of Marine Resources Fisheries Extension Service is probably unique in the country for its non-academic affiliation and practical approach to practical matters. All of the extension work and the information gathered by its agents would be of little use unless the material were quickly disseminated to the industry.

The Maine Department of Marine Resources Extension continues its uniqueness in its communication approach.

Realizing that few fishermen bother with "slick" newsletters, the extension agent writer began working on a tabloid size, newsprint-grade newsletter. You can't wrap fish in a shiny magazine.

Along the way it was discovered that a non-profit Maine company was planning the same size and format for its new publication. Forces were joined. The Extension Service maintains a current mailing list of all license holders in the state. Once a month, a computerized mailing list of all licenses is supplied the publication. In return, for a reduced cost, the publication, "Maine Commercial Fisheries," provides a full page for the Department's newsletter which is written in low-key style by the agent writer on the activities of the several divisions of the entire Department.

The agent writer also supplies the publication with articles and photos which are printed run-of-the-paper.

In this way, the Department's newsletter is packaged within the usual 28 pages of Maine commercial fishing news. It is mailed free, monthly, to every person who holds a Maine seafood license of any kind. Currently this is approximately 17,000 people.

The agent writer works on most every extension project and is intimately knowledgeable with the subjects he prepares for the publication.

The State of Maine fishermen appreciate their Department of Marine Resources fishery extension agents. But probably more importantly, the agents respect the fishermen. Both insist that Sea Grant's $75,000 has found a good home.

For the safety of their lives and ships,
Great Lakes mariners depend upon

NOAA's Paperback Best-Seller

BY GRACE WEGNER

They are known by many names. Lotsiya in Russian, Roteiro in Portugese, Portolano in Italian, Derrotero in Spanish, Handbuch in German and Instructions Nautiques in French.

But all have a common denominator. To mariners around the world they're known as "The Sailor's Bible."

In the United States, those published by NOAA's National Ocean Survey are known as Coast Pilots. Those published by the Navy are called Sailing Directions.

Of the 22,000 Coast Pilots sold in the United States, none is more sought after than that issued by NOAA's Lake Survey Center in Detroit for the Great Lakes, the often-stormy waters which have sent many a ship to its doom. (In the two decades from 1878 to 1898, almost 6000 ships were wrecked in the Great Lakes).

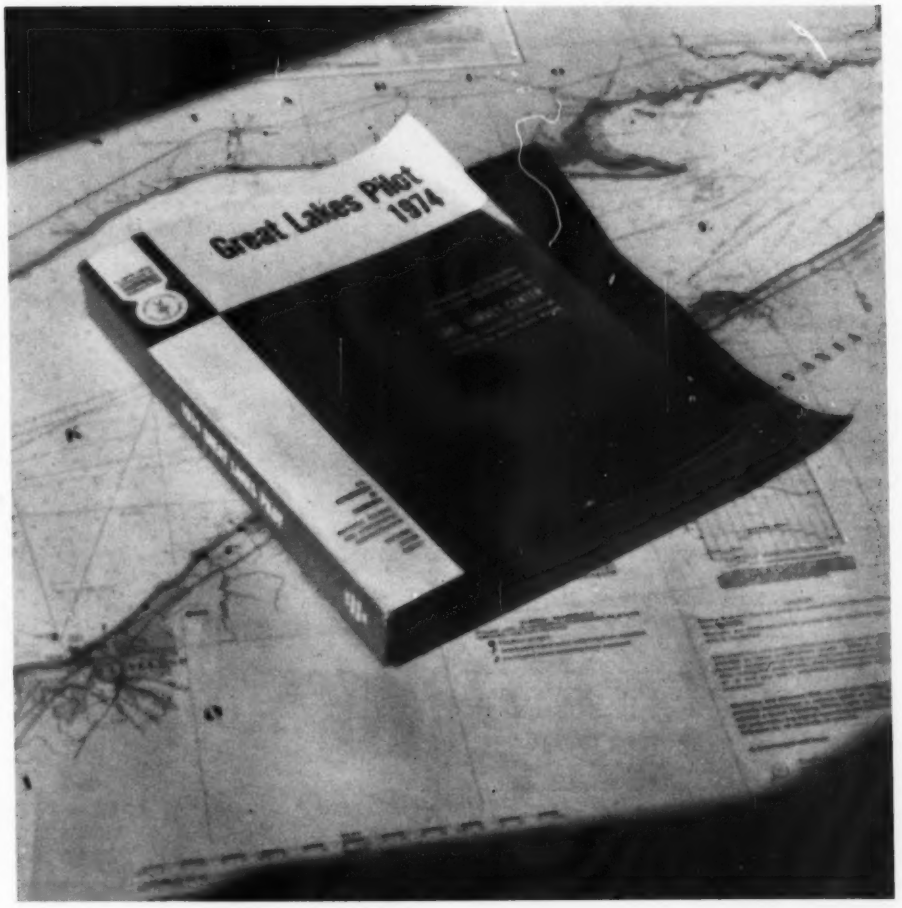
To those who navigate America's inland seas, the 1974 Great Lakes Coast Pilot is a best-seller, like those that have preceded it since 1889. The entire issue of 5000 copies was sold out by the end of the navigation season.

And for good reason, for the Coast Pilot is essential to the safety of each ship and its crew. The current 600-page edition, a far cry from the eight pages of the first 1889 publication, provides a word picture of material which cannot be shown on nautical charts. It describes such features as landmarks, harbor facilities, navigational aids and hazards, as well as listing many of the rules and regulations governing navigation in these much-used, economically important lakes.

Its information and accuracy have always been depended upon by the navigator, from the captain of the largest ore carrier to the skipper of the smallest pleasure craft. And the new edition each season is expected to be in the hands of the user by about April 1, when the navigation season begins.

Hence the need for haste in the preparation of the Coast Pilot. When the final survey cruise has been completed and field parties come in with their last-minute information and other agencies have submitted their final data, the editor must tuck up all the loose ends, so the book can be assembled, edited and sent off to the printer.

The story is told of one editor, not too long ago, who would gather all the material, take it into his office and shut himself off from everyone, with strict orders not to be disturbed for anything—"no phone calls, no visitors and no interruptions, except in case of fire."



The present editor, Walter A. Carpus, is not quite that harassed, possibly because he was recently granted an assistant, Richard J. Buszka. But there is a time when they need all the help they can get and that is around the first of March each year, when the words "The Pilot's here! It's down in the mail room," trigger 36 hours of hectic activity.

The manuscript copy of the Great Lakes Pilot has now been returned for final proofing and the checking, correction and return of this 600-page document must be completed in about 36 hours. Otherwise, the April 1 publication deadline cannot be met.

The Pilot editor, of course, has long ago lined up the teams who will be doing the painstaking job. Each team consists of two members—an experienced or knowledgeable editor and, since manpower has always been extremely limited, anyone who has a good knowledge of English, spelling and punctuation, and can be spared from other duties,

Changes for new edition of Pilot are noted by Assistant Editor Richard J. Buszka (right), and proofreaders Ella Shaw, Dorthea M. Jenkins, John F. Schmidt and Casimer (Casey) Zaranek work hard to insure that no mistakes appear in final product.

ST. CLAIR RIVER 201

Clearances across the Belle River at Marine City

No.	Location and name	Kind	Miles above mouth of river	Draw or span opening—clear width in feet proceeding upstream			Clear height in feet above water datum		Remarks
				Right	Left	Center	Low	High	
1	Submerged cable		0.17						
2	do		0.20						
3	Bridge Street bridge	Highway	0.48	60	60		7.1		Left draw only available.
4	Submerged cable		.55						Approximate depth not known.
5	Aerial cable		0.75						
6	Broadway (M-29) bridge	Highway	1.06			32.1	7.9		Fixed.
7	Aerial cable		1.11						
8	do		1.44						
9	do		1.55						
10	do		1.57						
11	Meisner Road bridge	Highway	2.57						

Signal for opening draws, 3 blasts (— — —).
Bridges are lighted according to U.S. Coast Guard regulations for lighting bridges.

channel, opposite Marine City, and on the line of the Chesapeake & Ohio Railway. A public wharf consisting of steel sheet piling, filled with gravel, approximately 397 feet long by 145 feet wide, serves as a loading wharf for the ferry-boat running to Marine City. A timber pile 55 foot causeway, 326 feet long by 20 feet wide, with concrete deck, connects this public wharf with the mainland. On the south side of this wharf and causeway is a refuge for small boats drawing up to 6 feet of water.

At Stokes Point, about 1¾ miles above the village there 60
is a loading used as a sand dock, comprising a gravel-filled pile pierhead 120 feet long on the river face by 100 feet wide, and a short approach 120 feet long by 20 feet wide, supported on piles; that depth at the face of the dock is about 15 feet. Stokes Point Wharf Light is displayed 45 50 feet above the water from a white circular steel tower with a red top, located about 20 feet shoreward from the southeast corner of the sand dock.

Wreck.—Between Marine City and the city of St. Clair, the submerged wreck of the steamer TOKIO lies 120 feet 55 from shore at a point 1,650 feet below the lower end of the Edison coal dock. In 1903, the wreck was removed to a depth of 14 feet.

Potable Water Intake.—See 42 U.S.C. 201, published in Certain Laws, preceding, and 42 C.F.R. § 72.121 of Rules and Regulations, preceding. A potable water intake crib of the East China Township in Michigan is located just upstream of the wreck of the TOKIO. The crib, with 16 feet of water over it, is 2,100 feet 126° from the Detroit Edison Co. stack at Revere Point. The crib is not marked. 65

Acceptable Vessel Watering Points.—See indented item "Acceptable Vessel Watering Points" for page reference to complete listing.

St. Clair, Mich.—The city of St. Clair is located about 7¼ miles north of Marine City. The Pine River is a small stream 100 to 120 feet wide, emptying into the St. Clair River near the southerly limits of the city.

Season of Navigation
(1955-56)

	Opening	Closing
Earliest date	Mar. 16	Nov. 26
Latest date	Apr. 2	Dec. 17

Improvement Work.—The improvement by the United States in the Pine River has consisted in dredging a channel 100 feet wide and 16 feet deep for a length of 2,000 feet from the mouth of the river, and thence 75 feet wide and 12 feet deep for a further length of 2,500 feet, a total length of 5,000 feet. The channel is subject to shoaling. No Government dredging has been done since 1939.

Soundings completed in the Pine River in May 1955 indicated controlling depths as follows: 10 feet for a distance of 500 feet above the mouth of the river; 6 feet for the next 2,000 feet, gradually decreasing to 4 feet at a distance of 1,000 feet above the mouth.

Harbor Facilities.—The city of St. Clair and Michigan State Waterways Comm. have jointly developed docking and mooring facilities on the Pine River, immediately upstream of the M-29 Highway Bridge. During severe

coerced or talked into doing it. With the possible exception of the Director and his assistant, most Lake Survey office people have at one time or another participated in this important project.

The Great Lakes Coast Pilot has borne that name only since 1951. Prior to then, it was simply called the "Bulletin" and yearly revisions were numbered consecutively.

The first Bulletin, dated October 1889, was written under the direction of O.M. Poe, Col. of Engineers, Bvt. Brig. Gen'l, U.S.A., in whose honor the Poe lock was named. This lock, originally built in 1896 and replaced by a bigger structure in 1968, is part of the world famous Soo Locks at Sault Ste. Marie, Michigan, the only water connection between Lake Superior and the other Great Lakes. The publication bore the title "Harbors ot the Great Lakes—Bulletin No. 1" and consisted of eight pages. It gave only the survey date and depth of anchorage and channel areas of some of the larger cities throughout the lakes. They were listed alphabetically, rather than by state or lake. A supplement was issued in February 1890 to add several additional cities, plus a little more detail on some of the original areas. Supplements have continued to be an integral part of the publication to this day.

By the turn of the century, the Bulletin (No. 11, 1901) was beginning to take on the general format it carries today, though each lake was printed in a separate booklet with an alphabetical designation. For instance, Bulletin 11A covered Lake Superior and the St. Marys River; 11B, Lake Michigan and

Green Bay; 11C, Lake Huron, St. Clair River, Lake St. Clair, and Detroit River; 11D, Lake Erie and Niagara River to Niagara Falls; and 11E, the Niagara River below Niagara Falls, Lake Ontario, and the St. Lawrence River to St. Regis. Each supplement included corrections to all five sections.

Throughout the years, as responsibilities for the Lake Survey increased, so too did the scope and contents of the Bulletin. The need for more and better information was clearly recognized. Commerce has been increasing almost fantastically. An article appearing in the Muskegon Chronicle dated Tuesday, December 30, 1890, states:

"The commerce of these great lakes is something to be proud of. During 23 and ½ days this year the tonnage passing through Detroit River amounted to 10,000,000 tons, *more than the combined clearances of all the ocean seaports of the United States.* This does not include traffice between lakes or local ports not passing Detroit. This year also 56 steamers costing $7,866,000 were built on the lakes . . ."

Another item dated March 5, 1891, states: ". . . The facts show not only radical changes that have taken place in the class of vessels used for transportation on the Great Lakes, but an increase in the tonnage and valuation during this brief period. In 1885 the net tonnage was 634,652, in 1890 it had reached 826,360, an increase of 191,708 tons. The estimated value of these vessels in 1886 was $30,597,450, and in 1890 the aggregate valuation was $58,128,500, an increase compared with 1886 of $27,531,050. Sailing vessels are fast giving place to vessels propelled by steam. "In 1866 there were but 21 propellers of over 1,5000 tons burden. In 1890 there were 110 propellers of this class."

The Lake Survey's Pilot (or Bulletin) was the offical publication used by these vessels. However, there were also two other "pilot" books published privately at this time (1889). They were: Thompson's Coast Pilot, originally published 1878, a copy of which is in the historical files of Lake Survey Center; and Scotts New Coast Pilot for the Great Lakes, printed by the Detroit Free Press "steam printing plant," a copy of which is displayed at the Dossin Marine Museum on Belle Isle in Detroit.

Bulletin No. 1 and its Supplements were printed in the Office, Chief of Engineers, in Washington, D.C. It was issued free to registered navigators, as a supplement to the users of the Great Lakes charts, which, until February 1890, had been provided free of charge as property of the vessel. Any surplus copies of charts were available to the public for 30 cents each from the Lake Survey, prepayment required.

On February 12, 1890, the Judge Advocate-General ruled that the language of the law "does not admit the free distribution of charts heretofore prevailing."

Until July of that same year, charts were sold at the uniform price of 30 cents each, but the Secretary of War directed that the future price per chart should be 20 cents, as that sum amply covered the cost of paper and printing, which determines the authorized charge. (The same rule applies today). The annual report for Fiscal Year ending June 30, 1891 showed that 500 charts were issued to U.S. vessels and officials; 599 were sold at 30 cents each; 5,339 at 20 cents; and 39 at 10 cents, for a total of 6,477 copies. The sum of $1,251.40 was turned in to the U.S. Treasury.

The front of Bulletin No. 1 stated, "To supplement the information given upon the Charts of the Great Lakes, and will be issued with those charts from the office of Colonel O. M. Poe, Corps of Engineers, 34 Congress Street, West, Detroit, Mich." No price was shown, indicating that they were probably provided free. Subsequent Bulletins contained an additional notice that stated, "All previous Bulletins should be destroyed." This note must have been taken literally by some of the old-timers, since a number of early issues are missing from Lake Survey files. Bulletin No. 55, dated April 1946, is apparently the first Pilot for which there was a charge. It contained over 500 pages and the bottom of the frontispiece states for the first time, "For Sale by the Superintendent of Documents, U.S. Govt. Printing Office, Washington 25, D.C., Price $1.50." (The 1974 edition is sold for $5.25 and can be purchased over the counter from the Lake Survey Center, 630 Federal Building, Detroit, Michigan, or by mail from the National Ocean Survey, Distribution Division (C44), Riverdale, Md. 20840).

The Pilot remained basically in the same format until printing of the 1965 edition. At that time, an extensive reorganization of its contents was completed to improve its clarity and legibility.

The following changes appeared in the 1965 edition:

a. All related data were placed under appropriate paragraph headings and considerable descriptive material was added.

b. Features subject to change, such as lighted buoy characteristics (which are contained in the U.S. Coast Guard's Light List), were removed. Changes in such features, including construction activities, dredging, etc., are noted in the supplements to give the mariner complete current information.

c. The portions of the text covering individual lakes were realigned to proceed in clockwise sequence around each of the lakes.

d. Excerpts from Federal laws and regulations were removed from the text, and appropriate data on laws and regulations were consolidated and placed in the front of the Pilot.

e. The order of appearance in the Pilot of the portions covering individual lakes and rivers, except the Hudson River, New York Canals, and Lake Champlain, was rearranged to read from seaward, starting with the St. Lawrence River and ending with Lake Superior at the head of the lakes.

Today's Pilot maintains this layout. It continues to provide the mariner with full descriptions of physical conditions of the waters charted and detailed information not adapted to adequate or prompt representation on the charts, including such items as U.S. laws and local ordinances governing navigation, bridge clearances, signals for locks and bridges, dimensions and capacities of dry docks and marine railways, and hydraulic and climatological data. The supplements are published monthly during the navigation season (May through October) to provide corrections and additions to the text necessitated by the constantly changing conditions in the navigational areas.

There are literally thousands of individual changes made from one year to the next. In addition to the material gathered by Lake Survey Center field personnel in their revisory and other surveys, data are also solicited from a larger number of other sources, including Federal and Canadian governmental departments and offices, various state and municipal interests concerned with these waterways and navigation, and other public and private interests concerned.

All of this material must be carefully verified before it becomes part of the new edition.

Thus, it can be seen that the editor of this guide to the natural transportation highway through this region of much beauty and economic importance has a monumental job on his hands. It is his responsibility to see that all the changes and additions find their way into the volume in the right spot. While he tries to keep up with changes as they occur throughout the year, it is only when the final survey cruise has been completed and the field parties come in with their last-minute information and other agencies have submitted their final data that his real headache begins. Then he must tuck up all the loose ends, so the book can be assembled, edited and sent off to the printer.

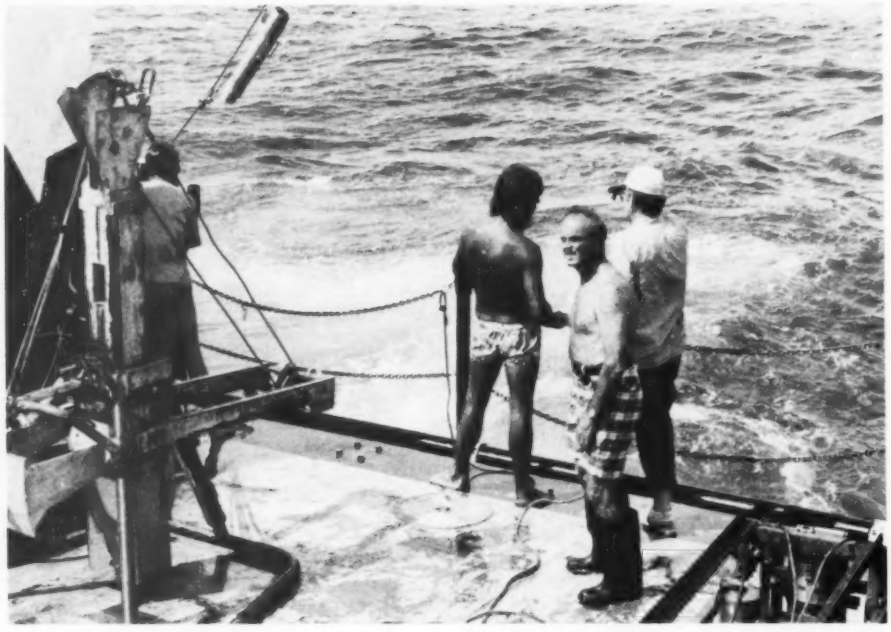
Today's editor, Walter A. Carpus, began his career with the Lake Survey Center after service with the Army Engineers in the Pacific during World War II and has been working with the publication for a number of years.

The latest double-column, 600-page issue, which even includes data on aircraft signals for rescue work, is a far cry from that first Bulletin of only eight pages, but the same care and pride go into its compilation. This is what has made it a best seller and generated praise in marine circles, such as, to quote an article by Jak Miner, "You Can't Call Yourself a Pilot Without the Pilot." This, together with the knowledge that there is something reliable and of interest in it for almost everyone—commercial shipper, boater, student, environmentalist, and researcher, to name a few—make all the effort worthwhile. However, there will no doubt always be a feeling of relief to those involved when the last page of the latest manuscript has been carefully proofread, the package securely wrapped, and it is finally on its way to the printer, to come back bound in its bright new cover as the next edition of the Great Lakes Pilot!

To protect the marine environment while reaping its mineral riches

DOMES Looks At The Nodule Zone

BY LOUISE A. PURRETT



Chief Scientist Dr. Roels (in boots, above) supervises lowering of an underwater camera which took thousands of photos of the ocean bed with its covering of manganese nodules. On the next page is shown a photograph of a sea cucumber and a brittle star. These were two of the rare inhabitants of the deep sea floor captured by the underwater camera.

In the middle of the Pacific Ocean, beneath three miles of equatorial waters, chunks of ore lie scattered across the top of the sediments. The ore chunks, or nodules, are rich in manganese, copper, nickel, and cobalt. They are part of a deep ocean world that has lain undisturbed by man for millions of years.

All that may soon change: within the next few years, full-scale operations may be underway to harvest the nodule wealth.

As part of a NOAA effort to assess the effects mining will have on the deep ocean environment, a team of scientists have conducted a four-week study of the pre-mining condition of a 20,000-square-mile (52,000-square-kilometer) segment of the north Pacific. The cross-shaped study area, located some 850 miles (1,360 kilometers) southeast of Hawaii, is part of an enormous nodule zone that extends from Mexico to the Marshall Islands.

The job of analyzing the reams of data these scientists collected will take months. But preliminary results are in, and they provide new insight into the marine environment of which the manganese nodules are an integral part.

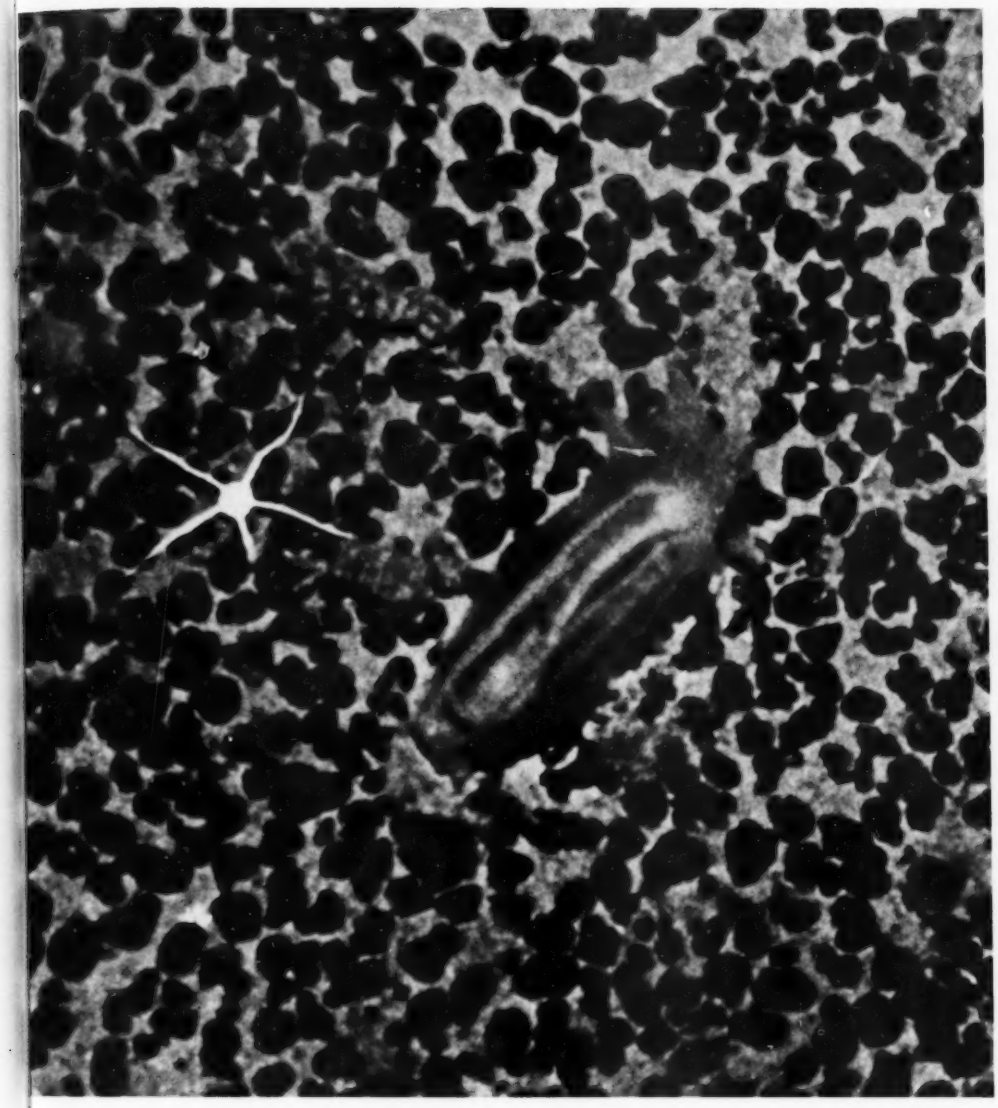
The study, led by Dr. Oswald A. Roels of Lamont-Doherty Geological Observatory and the City College of New York, was the first step in NOAA's Deep Ocean Mining Environmental Study (DOMES). For four weeks, Roels and 16 other oceanographers and technicians aboard the University of Hawaii's research ship *Moana Wave* examined the living organisms, sediments, currents, and waters of a study area centered on latitude 8 degrees, 27 minutes north, longitude 150 degrees, 47 minutes west.

Salinity, temperature, and the amount of dissolved oxygen were sampled at different depths at 54 stations in the research area. At 33 stations, the researchers took 12 samples from the surface on down to a depth of 200 meters (about 650 feet), testing for primary productivity, chlorophyll *a* (a measure of phytoplankton productivity), and nutrients. Another series of 12 samples from a depth of 1,000 meters (about 3,300 ft.) down to the ocean bottom was made at 39 stations. These samples were analyzed for particulate matter, organic carbon, organic nitrogen, and nutrients. Trace metals, especially the biologically active ones known to be present in manganese nodules—mercury, cadmium, arsenic, copper, lead, chromium, zinc, nickel, selenium, vanadium, beryllium—were tested at as many as 12 depths at each of 11 stations. Core samples of the bottom sediments are being subjected to geological analysis, while tiny organisms are being filtered out for identification. More than a ton of the nodules themselves were collected.

Four arrays of current meters, spaced from 10 to 2,000 meters (about 30 to 6,500 ft.) above the ocean floor were deployed at one of the stations to determine circulation patterns. An underwater camera took 2,204 photos of the sea floor, visual records of the amounts of nodules, the terrain, and fauna. In the upper levels of the water column, the researchers measure the intensity of light penetrating below the surface. The amount of light affects the rate of photosynthesis and thus the biological productivity of the waters.

Some deep-sea mining systems would bring large quantities of bottom water and some sediment to the surface; all would stir up clouds of sediments near the bottom. How would these foreign materials disperse, and what effects would they have on the character of the waters and on life forms?

The density of the bottom water compared to that of the surface water will determine whether it stays at the surface or sinks downward again, and differences in temperature and salinity determine the relative densities of the waters, says Roels. As it is transported upward, he adds, the bottom water is generally heated, and may reach the same temperature as water at the surface. The density of the heated bottom water would then depend on its salinity. "In our study areas," Roels reports, "the bottom salinity was generally the same as the sur-



face-water salinity." This means, he concludes, that bottom waters brought to the surface would probably remain.

These bottom waters would be rich in nutrients that could stimulate the growth of phytoplankton in the surface waters. To assess the effects of such an infusion of bottom water into the water column, the DOMES researchers collected water samples from 10 to 12 depths in the upper 150 meters of water and analyzed them for amounts and species of phytoplankton. The depths sampled were chosen according to thermal structure and light penetration, or the percent of sunlight reaching the ocean surface that a given depth receives.

In the shipboard laboratory, Roels' team made up varying mixtures of sediments, bottom water, and surface water and incubated them for 24 hours under natural sunlight filtered to simulate the different light levels received by the surface water samples. The results were no surprise: phytoplankton development was generally proportional to the amount of nutrient enrichment. But, Roels adds, deep water discharged at the surface will probably amount to less than one percent of the total mixture.

Other experiments tested the effects of various nutrients on samples of surface water. Thousands of analyses of nutrients, alkalinity, and oxygen content were conducted on ship.

There was also the possibility that mining might revitalize spores that have lain dormant in the sediments for ages, spores whose natural enemies may have long since disappeared. The researchers did find a series of phytoplankton spores buried in the sediments which bloomed to life when brought to the surface and exposed to light.

So far, 2,204 photographs of the bottom have been printed, and a fourth of these have been examined. The census of large animal life caught by the underwater camera includes: 111 sea cucumbers, 11 tunicates, 9 brittle stars, 9 anemones, 5 sponges, 3 sea stars, 2 rat-tail fish, one bivalve, and one coral. About 12,000 square meters (14,400 square yards) of ocean floor is visible in these 600 photos, and it seems to have a population density of about one large organism per 100 square meters.

One of the sediment samples has been analyzed and found to contain four species of foraminifera—tiny creatures with delicate calcareous skeletons—and a few individuals belonging to several other groups of organisms. The bottom samples also included an assortment of relics such as squid beaks, shark teeth, and whale earbones.

Within a few years, commercial mining ships may be sucking and scraping away at such Pacific nodule beds. The goal of the DOMES project is to determine, in advance, what the effects of mining operations might be, and to find ways to minimize any potentially destructive impact, or even derive some benefits for the environment. The long-term project is directed by John W. Padan of the Pacific Marine Environmental Laboratory in Seattle, one of NOAA's Environmental Research Laboratories.

The DOMES plan is to focus on the rich north Pacific nodule zone, which would probably be the first to be mined. Preliminary assays of the nodules there average as much as 35 percent manganese, 1.4 percent nickel, 1.2 percent copper and 0.25 percent cobalt—higher concentrations than some ores now being mined on land.

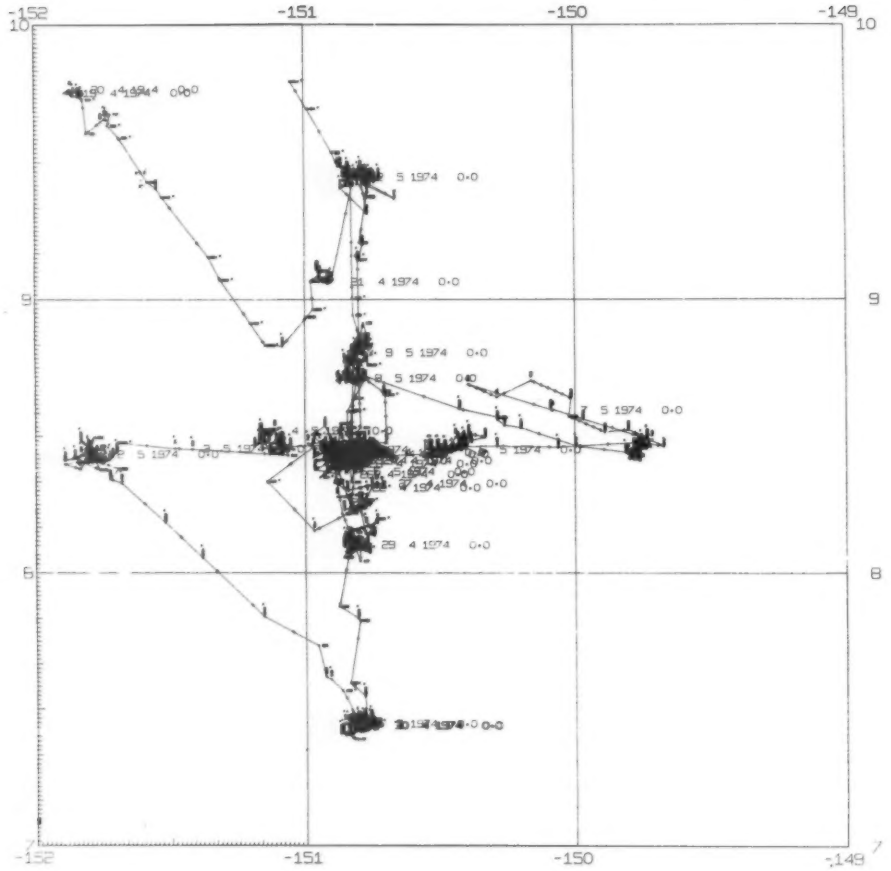
Manganese nodules were discovered over a century ago, and some were collected on the 1872 voyage of the *Challenger*. But only recently have the equipment and skills necessary to collect and refine the ore on a commercial scale begun to be developed—hastened by the depletion of mineral resources on land.

To evaluate the environmental impact of nodule mining, the original condition of the marine environment must be known. So the first step of DOMES is baselines—detailed environmental descriptions of the pre-mining condition of the water column and the top layer of sediment at selected sites in the nodule zone. Roels' study was the first of several baseline studies planned for DOMES.

Under DOMES, at least two other ocean sites, located in areas with different oceanographic characteristics, may be subjected to similar scrutiny on a seasonal basis to complete the baseline studies.

Roels' preliminary results suggest that the first steps in the mining process—retrieving the nodules and transporting them to the surface—could cause relatively minor environmental damage. But, he cautions, the processing and extracting these nodules at sea could be far more hazardous unless adequate precautions are taken. At present, however, most corporations are planning, at least at first, to process the ore ashore.

The next step planned for the project is to monitor industrial tests and prototype mining operations. Two main types of mining systems are being developed: hydraulic systems, which act like overgrown vacuum cleaners to suck nodules to the surface; and the continuous line bucket system, which is simply a series of buckets strung like beads on a cable that drop from the mining vessel's prow, scrape along the ocean bottom and rise, laden with nodules, to the stern of the ship. Both systems may destroy some deep-



(Top) the Moana Wave, *a University of Hawaii ship used in the NOAA study of pre-mining conditions of the marine environment in the Pacific zone of manganese nodules. (Below) A composite map of the cruise track in the DOMES north Pacific study area. The map was drawn by computer from data obtained by the* Moana Wave's *satellite navigation system.*

water organisms in their paths, stir up sediment, and bring bottom materials upward.

What happens to sediments stirred up by mining operations will depend on such yet-to-be-determined factors as the density of the sediments and the strength and direction of near-bottom currents. In Roels' opinion, the biological effects of such sediment disturbances may be reduced by "the relatively low density of the near-bottom prowlers and the fact that the sedimentary material arrived on the sea floor as a result of natural sedimentation processes." On the other hand, he adds, "it remains equally clear that local disturbance of sediment may have a certain impact on the deep-sea fauna and flora," particularly animals with a very slow reproductive cycle. Roels suggests that if bands of sea floor were left undisturbed in a mined area, "the deep-sea fauna and flora should be able to reestablish themselves in those areas where the dredge heads have destroyed it."

After mining tests are completed, NOAA would continue to observe the sites, to see whether the ecology returned to "normal" after mining operations ceased and how long the process required. Experiments in shore-based laboratories would help define the mechanisms by which mining could alter the environment.

World reserves of nickel, copper, cobalt, and manganese are expected to be exhausted within a few decades. Estimated resource potential for these metals—reserves plus other deposits that may eventually become available—covers a considerably longer time span. But, says Padan, there are no guarantees.

"Deep ocean manganese nodules offer the potential of a vast new source of nickel, copper, cobalt, and manganese," Padan indicates. He estimates that a 10,000-ton-per-day mining unit (a size within the range being discussed by industry), operating with reasonable efficiency, could annually produce 41.5 thousand tons (37.6 million kilograms) of nickel, 33 thousand tons (29.9 million kilograms) of copper, 8,000 tons (7.3 million kilograms) of cobalt, and 977 thousand tons (886 million kilograms) of manganese.

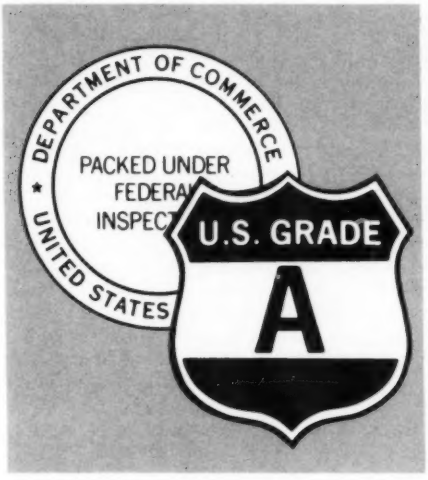
As mineral resources on land are depleted, the mining industry is turning to the vast, untapped wealth of the seas. A number of corporations have already taken the first steps toward recovering this wealth, and NOAA scientists estimate that full-scale commercial mining of manganese nodules could begin around 1980. Roels believes the time will come sooner—perhaps within 2 years. "It is essential," concludes Padan, "that the environmental impact of manganese nodule mining be well defined and its implications understood before deep-sea mining is attempted on a large scale."

Roels agrees: "We now have a unique opportunity in the world's history to determine what the environmental effects of a new endeavor are going to be *before* it begins. The beginning of mining is imminent. We have the chance to steer it in the right direction—to benefit, rather than harm, the environment. We must seize that opportunity."

NMFS inspection program promotes top quality fishery products

Helping The Housewife Choose

BY GERALD D. HILL, JR.



What do you look for when purchasing fish at the market?

If you look for the same characteristics that Department of Commerce inspectors seek, you will be assured of healthy, tasty seafood meals.

Just last March, NOAA endorsed a new and revitalized voluntary inspection program that had been conceived by the National Marine Fisheries Service. The program was completely reorganized and a new national program manager, Thomas J. Billy, was assigned to direct it.

"Our inspectors are trained experts in seafood quality and safety," says Mr. Billy, "but any housewife can, and should, use many of the same criteria when she goes to the store to buy fish for her family." Here, he says, are some important things she should look for:

Fresh fish—First look at the eyes, which should be bright, clear, and protruding slightly from the head. If they have sunken into the head, the fish probably is not fresh.

Next look at the gills. They should be bright red or pink. As quality slips, the gills quickly begin to darken.

If the fish is drawn or gutted, turn it over and look at the intestinal cavity, which should be pink and have a fresh clean appearance.

Any fresh fillet or cut of fish should have firm flesh, which will spring back when gently pressed with the finger. The skin should be shiny, and fresh fish will have a mild, fresh, clean odor.

Crabs and lobsters—If they are fresh, look for movement of the legs, to ensure that the animals are alive. If they are cooked, look for a bright orangey-red color, and make sure that they have no disagreeable odor.

Clams and oysters—They should be alive when bought in the shell. If the shells are closed, the shellfish are alive. If the shell is open, tap it gently to see if it closes. If it doesn't, reject it.

Shucked oysters—Check them for plumpness and to see that they have a natural creamy color and a clear liquid.

Frozen fishery products—Make sure that the fish is solidly frozen and has no objectionable odor.

It may be glazed (fish processors will sometimes dip the frozen fish into water one or more times, quickly freezing the water, so that the entire fish is covered with an icy glaze that protects the flesh from dehydration). As long as the glaze remains intact and the fish remains frozen, it will keep quite well. If the glaze has melted or is chipped, the unprotected flesh may turn a cottony white. This is freezer burn, and even though the fillet is frozen, the exposed flesh has begun to suffer a cellular breakdown. Reject the fish.

"For additional protection to the consumer," says Mr. Billy, "our inspectors will also make sure that fishery products have not begun to decompose or turn rancid, and that products are free from extraneous materials. Packages must also be properly filled, of the proper weight, and labeled correctly to identify the contents."

For many years the Department of Agriculture has conducted a mandatory inspection program on all red meat and poultry, to ensure that consumers obtain a safe, wholesome, acceptable quality product. In addition, the Food and Drug Administration is responsible for the safety of food products, and it carries out its responsibilities through an enforcement program in which both food products and plants are spot-checked for compliance with regulations. However, there is no mandatory inspection of all fishery products to ensure that they are not only safe, but wholesome and of acceptable quality.

Voluntary inspections are authorized under the Agricultural Marketing Act of 1946, as amended by the Fish and Wildlife Act of 1956, and a program was instituted by the Agriculture Department at that time. After passing to the Department of Interior and then to NOAA, it was thoroughly revitalized last year.

"We have developed new services, and in particular we overhauled existing services to fit the needs and the pocketbooks of smaller firms, which make up such a large proportion of the fishing industry," said Mr. Billy. Lines of communication between the inspection service and the fishing industry were expanded and improved, and greater flexibility to handle new business was introduced.

An all-out effort was made to gain industry support for the revamped program and expand industry participation in it. Numerous meetings with representatives of industry were held to explain the new inspection program and to solicit their support. NOAA has also planned vigorous promotion campaign in conjunction with industry and with firms now participating in the program, to make consumers and product users aware of the benefits of inspected products.

"When buying fishery products at your store, there are two marks that you should look for, to show that they have had the benefit of our inspection services," stresses Mr. Billy. "First is the new U.S. Department of Commerce Packed Under Federal Inspection (PUFI) mark. It is given only to inspected seafood products, and it attests that they have been statistically sampled at the time of processing and found to be safe, wholesome, and of good quality.

"The second is the Grade A shield. This is given only to top quality products—products that are uniform in size, free of blemishes and defects, in excellent condition, and that possess a fresh flavor and odor characteristic of the species."

He explained that the Federal inspection program has grade standards for several products, to identify their relative value and quality. The shield is awarded only to superior products.

The PUFI inspection mark attests to the safety and wholesomeness of the lot when

inspected, as well as the conditions under which the lot was processed. The Grade A shield, on the other hand, attests to a high level of quality in the fishery product at the time it was inspected. By itself, the Grade A shield lets you know that the product has been graded as well as packed under Federal inspection.

During the planned revitalization of the inspection program, NMFS surveyed the States to find out if they had an interest and capability to participate in a cooperative State/Federal inspection program, whereby they would carry out the progam for NOAA and thus eliminate the need for increased Federal employment. Twenty-four states have expressed a positive interest and NMFS is taking action to make final agreements with some of them.

Food and Drug Administration recognition was sought and received for the new program. The fisheries inspection expertise found in the National Marine Fisheries Service will be more effectively used through the recent signing of a Memorandum of Understanding between NOAA and FDA.

Under the new program there are four types of inspection services available to assist the processor: inplant product inspection, plant sanitation inspection, lot inspection, and consultative services.

Inplant product inspection is the most encompassing of the inspections and to some degree includes the other inspection services offered. A contract inspector in a processing plant oversees preparation, processing, and packaging operations. He monitors the quality of the raw materials being used, examines the product as it is being processed and tests samples of the finished product. He constantly monitors the sanitation of the plant, assists the management in evaluating new products and plant improvements. The processor pays about $14 per hour for this service.

Depending on the size of the plant and the services wanted by the processor, the inspector may be in the plant from four hours a week to a full-time schedule of eight hours a day during the entire year. Inplant product inspections are used primarily by producers and packers of fisheries products.

A new inspection service offered is the Sanitarily Inspected Fish Establishment (SIFE) in which the plant itself is the target of inspection rather than the items produced. The NMFS inspector works with plant personnel in conducting a series of sanitation surveys which pinpoint the strengths and weaknesses of the facility and the food processing system. He then proposes necessary improvements in hygienic conditions and practices. Once the weaknesses have been corrected he visits the plant once or twice a week to see that the sanitary conditions are maintained.

After all sanitary requirements are met, the company is awarded a certificate stating that its plant facilities meet NOAA requirements. The cost of the service is about $17.50 per hour.

Lot inspections are used primarily by hrokers and buyers of fisheries products in the distribution chain. These inspections are usually conducted in processing plants, warehouse, cold storage plants, or terminal markets. In a lot inspection, the inspector is concerned with the quality of the product and is not involved in processing or packaging of the product. He takes several samples of the raw product and examines them to determine the quality and condition of the lot. If the inspector approves the lot, then the processor who buys that lot of fisheries products knows that it has been statistically sampled and approved in accordance with DOC standards. Cost of this service is about $21.00 per hour.

Consultative services are used by processors, packers, and brokers who contract for specific services such as plant surveys, sanitation evaluations, new product evaluations, and label and product inspections. These are normally a one-time service, and the inspector is not in the plant as often as he is when the plant has an inplant product or SIFE inspection. This service costs about $17.50 per hour.

I recently visited a processing plant that uses the inplant product inspection to learn more about the program. It is a large plant with over 400 employees, operates two shifts seven days a week, and processes about four million pounds of fishery products a year. Approximately 60% of this total production is inspected and carries the U.S. Department of Commerce Grade A shield or Packed Under Federal Inspection mark.

The six-year-old plant never closes and when the processing lines are still, the cleaning crews are busy.

There is notable absence of fish odor.

Everyone is conscious of the high sanitation standards maintained throughout the plant; the workforce is uniformed in white, wears plastic gloves while working around the product; and all hallways and areas outside the production room are mopped and buffed daily.

An exterminator treats the plant weekly, material used in making batter and breading is stacked on pallets in a special air-conditioned area and is used within 60 days of arrival in the plant. The Department of Commerce inspector examines this area bi-weekly.

A large part of the plant production is preparing fish portions, both raw breaded and breaded precooked, and breaded fish sticks used by hotels, schools, hospitals, caterers, and other large users of seafood products.

There are six processing lines in the plant, all capable of processing six to nine thousand pounds of fishery products an hour.

The raw product enters the plant in 18½ pound frozen blocks of fish fillets. As they enter the processing cycle they are sawed with a band saw into the proper size and shape, placed on a conveyor belt, and moved down the line. After being cut they move through a shallow trough containing the batter, then move to another machine which breads them as they are moving down the line. The fish portions are still frozen solid as they move through an oven of approximately 385° which precooks the portion just enough to seal the portions in the breading. From here they pass through a quick freeze machine set at temperatures of 40° below zero which freezes the whole portion again; they then pass between rows of workers who pack them into boxes. The boxes are then weighed, labeled, wrapped in plastic, passed through a metal detector, packed in larger crates, and then placed in a 0° storage area to await shipment.

Those fish portions with corners broken off, holes in them, or otherwise imperfect are packed and labled as being below the normal weight of a package and sold as seconds.

The Department of Commerce inspector monitors the entire process continually for any sanitary violations.

Of equal importance to the inspector is making sure that the proper flesh-to-breading ratio is maintained. The National Marine Fisheries Service has established criteria for the amount of flesh that must be in the breaded portions in order for the company to use the Grade A shield and inspection mark. Raw breaded portions must have 75% flesh, fish sticks, 72%, and precooked breaded portions must have 65% flesh.

There are two methods the inspector can use to determine the amount of fish flesh in the stick or portion. He may use the on-line method or the scrape method. If the on-line method is used, the inspector goes to the production line and gets a completed box of 15 portions. He then goes to the front of the line and gets 15 portions which have been cut to the proper size but have not been otherwise processed. The inspector then weighs the portions and uses a mathematical formula to determine the percentage of flesh found in the completed portion.

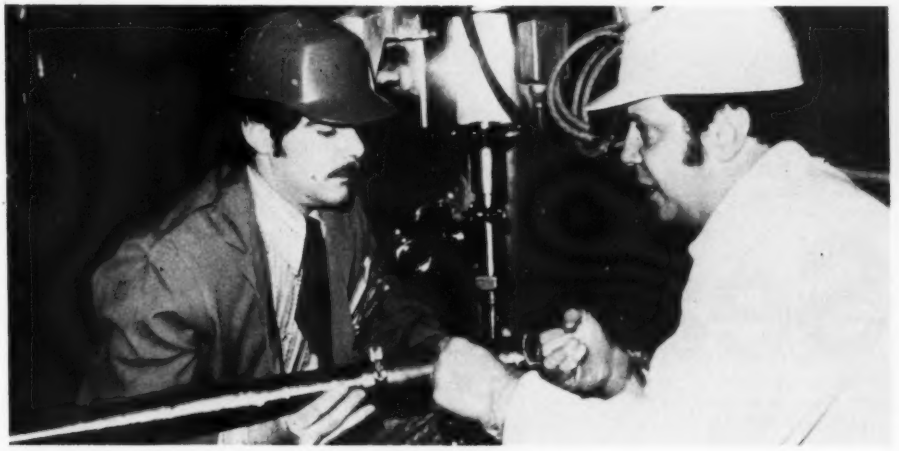
If the scrape method is used, the inspector takes samples of the finished breaded product and weighs them. He then scrapes the batter and breading from the flesh and weighs the flesh again. By using another formula he is able to determine the ratio of flesh to breading. If the amount of flesh is below the minimum requirement then additional samples are taken from the line and tested to verify the original results. This retesting is done several times while production corrections are being made.

After the sample has been tested for proper weight and ratio of breading to flesh it is cooked, split, and checked for odor and taste, and to see that there are no bones or other foreign matter in the portion.

Each processing line is checked at least once an hour.

In addition to the inspection of the products on the line, the frozen blocks are checked periodically in the company laboratory. The frozen blocks are allowed to defrost, are then broken apart and examined under strong light for bones and other foreign matter. If the block is below standard then the entire lot is returned to the source.

The inspection service benefits both the fisheries industry and the consumer. Of course, the most obvious benefit to industry is that it increases the consumers' confidence in the products, thus giving the company an advantage over his competitors. By complying with the requirements of the program he is entitled to use the inspection mark and the shield on the products he



Inspectors perform a variety of tests to insure that fish products meet high safety and quality standards. Tests include cutting open processed product (upper left) for closer examination and checking for plant sanitation problems (above). Inspectors also keep watchful eyes on packaging of such items as breaded fish sticks (left) and peer intently into raw filets to make sure no bones or foreign matter are present.

markets which increases their appeal to the consumer. The inspection service also gives the businessman the opportunity to use the expertise available in the Department of Commerce in developing and improving his quality control programs and also provides him with certificates of quality of his product which are recognized as evidence of fact in the courts. It gives him a means of determining if the terms of his contracts and purchase orders have been met and that he has in fact gotten what he has ordered. The inspection service gives him a means of establishing the inventory loan value of his products, assists him in settling claims for damage to his product while it is being shipped and gives him a basis for resolving disputes over product quality.

Research and laboratory resources needed to solve technical and marketing problems are available to the businessman as well as a source to develop processing specifications for nonstandard fishery products.

Most people are interested in knowing the inspection service benefits the consumer by making important contributions in four major areas of consumer concern about food products. All consumers are interested in quality, purity, sanitation, and economy when buying food products and the inspection program satisifes these essential needs. The inspection mark and the Grade A shield tells the housewife that the product has been statistically sampled and examined to determine whether it is of good quality; is safe; was produced, processed, and packaged under sanitary conditions; and that the food she is buying has been truthfully labeled and packaged.

The revitalization of the inspection program has brought encouraging results. Since June the number of firms participating in the program has almost doubled and the outlook for more participation by the industry is encouraging.

The goal of the USDC inspection program is to assure the public of a uniformly nutritious and palatable food that has been prepared under sanitary conditions. Many of today's fishery product producers have enormous pride in their products and consistently turn out high quality food items. Nevertheless, when shoppers go to the market, they really don't know if the seafood they buy was turned out by highly conscientious processors. Experience may have told the buyer which products are the best quality, but if the product bears the U.S. Department of Commerce inspection mark the shopper does not have to guess and will have assurance that the product has been statistically sampled and approved in accordance with DOC standards.

Sea Fare

Seafood is in Style

The National Fisheries Education Center of the National Marine Fisheries Service announces its showing of seafood styles.

This year's imaginative line features a wide variety of color, flavor, and texture in designs that "go with" everything. Many of the finest food fashions come from the famous "Kitchen With The Window on the Water," and this spring, Service Home Economists have reached new heights by dressing up several "damsels of the deep" in stunning seafood styles that should win for them the "Best Dressed Dishes of the Year" award.

Something Basic

4 cans (6½ or 7 ounces each) tuna
2 cans (10½ ounces each) condensed cream of mushroom soup
⅔ cup dry bread crumbs
½ cup finely chopped onion
4 eggs, beaten
½ teaspoon salt
⅛ teaspoon pepper
2 packages (9 ounces each) frozen cut green beans
¼ cup diced pimiento
½ teaspoon dill weed
⅛ teaspoon pepper
1 cup shredded sharp cheddar cheese
Paprika

Drain and flake tuna. Mix tuna with ½ cup soup, dry bread crumbs, onion, eggs, salt, and pepper. Line a well-greased baking dish, 13 by 9 by 2 inches, with tuna mixture letting the mixture extend up the sides of the dish. Cook beans according to directions on package, omitting butter or margarine. Combine beans, remaining soup, pimiento, dill weed, and pepper. Pour bean mixture into tuna lining and spread evenly. Place cheese around edge of bean mixture. Sprinkle cheese with paprika. Bake in a moderate oven 350° F., for 30 to 45 minutes. Makes 12 servings.

Note: This casserole may be prepared a day ahead and refrigerated until baking time.

Evening On The Town

- 1½ pounds frozen raw, peeled, cleaned shrimp
- ½ cup chopped celery leaves
- ¼ cup whole mixed pickling spice
- 2 quarts boiling water
- 2 cups sliced onions
- 5 bay leaves
- 1½ cups salad oil
- 1½ cups white vinegar
- ¼ cup chopped pimiento
- 2 tablespoons capers and liquid
- 1½ teaspoons celery seed
- 1½ teaspoons salt
- ¼ teaspoon liquid hot pepper sauce
- Salad greens

Thaw frozen shrimp. Rinse with cold water. Tie celery and pickling spice loosely in a piece of cheese cloth. Place in boiling water and simmer for about 10 minutes. Add shrimp. Simmer for 5 minutes. Drain. Arrange sliced onions and shrimp in alternate layers in a bowl. Add bay leaves. Combine remaining ingredients except salad greens. Mix thoroughly and pour over onions and shrimp. Cover and chill for about 6 hours, stirring occasionally. Drain. Serve on salad greens. Makes 6 servings.

In the Country

- 1 can (16 ounces) salmon
- ⅓ cup chopped celery
- ¼ cup chopped onion
- 3 tablespoons butter or margarine
- 3 tablespoons flour
- 1¼ teaspoons salt
- 2 cups salmon liquid and milk
- 1 package (10 ounces) frozen mixed vegetables
- 2 cups milk
- ½ teaspoon dill weed

Drain salmon and reserve liquid. Break salmon into large pieces. Cook celery and onion in butter until tender in a 3-quart saucepan. Blend in flour and salt. Add salmon liquid and milk and cook until thickened, stirring constantly. Add frozen vegetables. Cover and simmer 15 to 20 minutes or until vegetables are tender. Add remaining milk, dill weed, and salmon. Heat. Makes 6 servings.

Before the Concert

- 1 pound blue crabmeat, fresh or pasteurized or
- 3 cans (6½ or 7½ ounces each) crabmeat
- 24 fresh mushrooms, approximately 1½ inches in diameter
- ½ cup chopped mushroom stems
- 2 tablespoons butter or margarine, melted
- 1 egg, beaten
- 2 tablespoons chopped parsley
- ½ teaspoon salt
- ¼ teaspoon finely chopped garlic
- Dash white pepper
- 2 tablespoons grated Parmesan cheese

Thaw frozen crabmeat. Drain crabmeat. Remove any remaining shell or cartilage. Rinse mushrooms in cold water. Dry mushrooms and remove stems. Cook chopped mushroom stems in butter for 5 minutes. Combine all ingredients except cheese and mushroom caps. Stuff each mushroom cap with about 2 tablespoonsful of crab mixture. Sprinkle with cheese. Place mushrooms on a well-greased baking pan, 15 × 10 × 1 inch. Bake in a moderate oven, 400° F., for 12 to 15 minutes or until lightly browned. Makes 6 servings.

Note: Omit the salt when using canned crabmeat.

French Flair

- 2 pounds North Pacific halibut steaks, fresh or frozen
- 1/2 cup French dressing
- 2 tablespoons lemon juice
- 1/4 teaspoon salt
- 1 can (3 1/2 ounces) French fried onions
- 1/4 cup grated Parmesan cheese

Thaw frozen steaks. Cut into serving-size portions. Place fish in a shallow baking dish. Combine dressing, lemon juice, and salt. Pour sauce over fish and let stand for 30 minutes, turning once. Remove fish from sauce and place in a well-greased baking dish, 12 × 8 × 2 inches. Crush onions. Add cheese and mix thoroughly. Sprinkle onion mixture over fish. Bake in a moderate oven, 350° F., for 25 to 30 minutes or until fish flakes easily when tested with a fork. Serves 6.

All Dressed Up

- 3 pounds pan-dressed rainbow trout or other pan-dressed fish, fresh or frozen
- 1 cup buttermilk
- 1 package (1 3/4 or 1 3/8 ounces) onion soup mix
- 1 cup flour
- Lemon wedges
- Fat for frying

Thaw frozen fish. Clean, wash, and dry fish. Place in a single layer in a shallow baking dish. Combine buttermilk and soup mix. Brush fish inside and out with sauce. Let stand 1 hour. Remove fish from sauce and roll in flour. Fry fish in hot fat at moderate heat for 4 to 5 minutes or until brown. Turn carefully and fry 4 to 5 minutes longer or until brown and fish flakes easily when tested with a fork. Drain on absorbent paper. Serve with lemon wedges. Makes 6 servings.

New Pattern For Spring

- 1 pound frozen, peeled, deveined shrimp
- 1 cup long grain rice (not quick cook)
- 1/2 cup sliced green onion with 2 inches of tops
- 1/4 cup cooking oil (or half cooking oil and half olive oil)
- 1 can (13 3/4 ounce) chicken broth
- 1/4 cup water
- 1 1/2 teaspoons salt
- 1/4 teaspoon leaf thyme
- Dash pepper
- 1/2 package (10 ounce) frozen peas, thawed
- 1/2 cup sliced pitted ripe olives
- 1/4 cup chopped pimiento

Thaw frozen shrimp. Heat rice and green onion in oil in large skillet or Dutch oven, stirring constantly. Add chicken broth, water, 1 teaspoon salt, thyme, and pepper; mix well. Bring to boil. Cover and cook over low heat 15 minutes or until rice is tender. Add shrimp, peas, olives, pimiento, and remaining 1/2 teaspoon salt; mix carefully. Cover and cook over low heat 5 to 8 minutes or until shrimp is tender. Makes 6 servings.

Devil May Care

1 pound scallops
1 clove garlic, chopped
2 tablespoons butter or margarine, melted
2 tablespoons flour
1/2 teaspoon dry mustard
2 teaspoons prepared horseradish
1/2 teaspoon celery salt
2 tablespoons chopped parsley
1 tablespoon lemon juice
Few grains pepper
1/2 cup buttered crumbs
Paprika

Rinse scallops well to remove any sand. If large, slice them. Cook garlic in butter or margarine until golden. Remove garlic and discard. Blend in flour and seasonings. Add scallops and cook from 4 to 5 minutes, stirring constantly. Place in 4 greased individual shells or custard cups. Top each shell with 2 tablespoons buttered crumbs. Garnish with paprika. Bake in moderate oven, 350° F., for 20 minutes. Serves 4.

That Oriental Touch

2 pounds fish fillets, fresh or frozen
2 cups pared chopped apple
1/2 cup chopped onion
1/2 cup butter or margarine
1/4 cup flour
2 teaspoons curry powder
1 teaspoon salt
1/4 teaspoon pepper
1 3/4 cups water
3 cups hot cooked rice
3/4 cup chopped green onion
3/4 cup chopped peanuts
3/4 cup chopped tomatoes

Thaw frozen fillets. Cut fillets into 1-inch cubes. Melt butter in a 12-inch fry pan. Add apple and onion and cook until tender. Blend in flour and seasonings. Add water gradually and cook until thick, stirring constantly. Add fish. Cover and cook over low heat for 7 to 10 minutes or until fish flake easily when tested with a fork. Serve over rice with the following curry condiments: chopped green onions, peanuts, and tomatoes. Makes 6 servings.

South of the Border

1 cup chopped onion
2 tablespoons cooking oil
1 can (10 ounce) tomatoes and green chilis
1 can (8 ounce) tomato sauce
1/2 cup water
4 teaspoon chili powder
1/2 teaspoon oregano
1/4 teaspoon salt
2 cans (7 1/2 ounce each) snow or other crabmeat, drained
1 1/2 cups shredded Monterey jack or Cheddar cheese
1/3 cup chopped pitted ripe olives
12 corn tortillas
Cooking oil for frying tortillas
Dairy sour cream (optional)

Cook onion in oil until tender, not brown. Add tomatoes and green chilis, tomato sauce, water, chili powder, oregano, and salt; mix well. Bring to a boil. Cover and simmer about 15 minutes to blend flavors. Combine crabmeat, 1/2 of the cheese, olives, and 1/2 cup of sauce; mix. Fry tortillas, one at a time, in shallow medium-hot oil just until they are limp and begin to blister. Remove from pan and drain. Dip one tortilla at a time into remaining hot sauce. Lay flat on baking sheet. Fill each with about 1/4 cup of crabmeat mixture. Roll up; place flap edge down in shallow 2-quart baking dish. Spoon remaining sauce over top and sprinkle with remaining cheese. Bake in moderate oven, 350° F., 20 to 25 minutes or until hot. Serve topped with sour cream, if desired. Makes 6 servings.

DENT HONORS NOAA STAFFERS

NOAA employees received eight Gold Medal Awards and 17 Silver Medal Awards from Secretary of Commerce Frederick B. Dent in an honors award program in October.

Recipients of the Gold Medal, the Department's highest honor,

Dr. John R. Apel, Director of the Environmental Research Laboratories' Ocean Remote Sensing Laboratory at the Atlantic Oceanographic and Meteorological Laboratories in Miami, Fla. Dr. Apel has made outstanding scientific and technical contributions to the National Aeronautics and Space Administration's Earth and Ocean Physics Applications Program. From this program grew the concept of SEASAT-A, the Nation's first dedicated ocean-looking satellite.

Dr. Ben B. Balsley, a Physicist in the Scatter Radar Studies Program of ERL's Aeronomy Laboratory in Boulder, Colo. Dr. Balsley is a leader in the radar study of field-aligned irregularities in the ionosphere, including irregularities in the equatorial electrojet, the auroral electrojet, and equatorial spread F.

Dr. Joshua Z. Holland, Director of the Environmental Data Service's Center for Experiment Design and Data Analysis, in Washington, D.C. Dr. Holland has made major contributions to three large-scale scientific field experiments—the Barbados Oceanographic and Meteorological Experiment (BOMEX), the International Field Year for the Great Lakes (IFYGL), and the Global Atmospheric Research Program Atlantic Tropical Experiment (GATE). As chief scientist of the BOMEX Sea-Air Interaction Program, he provided on-site direction during the field operations.

Dr. Chester P. Jelesnianski, Storm Surge Specialist in the Marine Techniques Section of the Techniques Development Laboratory in the National Weather Service's Systems Development Office. Dr. Jelesnianski designed and developed an automated method of forecasting storm tides caused by hurricanes. His computer program called Special Program to List Amplitudes of Surges from Hurricanes (SPLASH) is activated by forecasters of the National Hurricane Center when a hurricane threatens the Atlantic or Gulf Coasts of the United States. SPLASH produces both a graphical portrayal and a digital printout of storm tide height along the coasts. He has also applied SPLASH to determine tide potential for various coastal areas.

Dr. William H. Klein, Director of the Techniques Development Laboratory in the NWS Systems Development Office, and, since July 1974, Acting Director of the SDO, at NWS Headquarters in Silver Spring, Md. Under Dr. Klein's expert and dynamic leadership, the TDL has become internationally known for its work in weather forecast and analysis technique development. His contributions have been not only in the area of overall management of TDL, but he has also provided effective technical leadership.

Dr. Reuben Lasker, Chief of the Stock and Recruitment Program at the National Marine Fisheries Service Southwest Fisheries Center in La Jolla, Calif. Dr. Lasker was recognized for his outstanding contributions as both scientist and scientific editor. In connection with his role as a scientist, he has made significant contributions to the solution of specific problems affecting the survival/mortality of fish larvae, as evidenced by his research efforts which resulted in the successful rearing of pelagic marine fish in a laboratory. For the first time, more than 30 species of pelagic fishes, including the commercially valuable sardine, anchovy, and mackerel, have been reared in a laboratory.

Allen D. Pearson, Director of the NWS National Severe Storms Forecast Center in Kansas City, Mo. Mr. Pearson's outstanding leadership and direct participation in the preparation of the forecast products of the NSSFC for nearly nine years have resulted in a steady improvement in tornado and severe thunderstorm forecasting. He has had the lead role nationally in the promotion of community preparedness against tornadoes and in the education of the general public in tornado safety.

Dr. Roland F. Smith, Chief of the Living Resources Office in the Office of Marine Resources at NOAA's Rockville, Md., Headquarters. Dr. Smith has shown outstanding leadership in the development and management of living marine resource programs, principally initiation of an internal review and evaluation of the options open to the United States for international management of fishery resources. This effort was essential to the development of the United States position for the United Nations Law of the Sea Conference held in Caracas, Venezuela, as well as for the establishment of a U.S. policy with regard to fisheries resources off its own coastline.

Silver Medals, were presented to:

Robert Belesky, a Weather Service Specialist at the NWS Office in Cincinnati, for his superior radar interpretations and outstanding performance under extreme stress during the violent outbreak of the April 3, 1974 tornadoes.

John R. Burke, Meteorologist in Charge of the NWS Forecast Office in Louisville, Ky., for his outstanding leadership and his direct participation in the operations of the Louisville WSFO which have fostered a high degree of capability among his staff.

Clarence L. David, Lead Severe Storms Forecaster at the NWS National Severe Storms Forecast Center in Kansas City, Mo., for his outstanding performance of duty as leading forecaster, Severe Local Storms, during the disastrous outbreak of tornadoes on April 3.

Denzil R. Davis, Assistant Director of the NWS Environmental Study Service Center at Auburn University in Auburn, Ala., for his significant contributions to the NWS Agricultural Weather Program as evidenced by practical applications of scientific research.

Commander Joseph W. Dropp, Commanding Officer of the NOAA Ship *Peirce*, for his outstanding technical and managerial leadership in the planning and development of an extremely effective training program for newly commissioned officers.

James B. Elliott, Weather Service Specialist at the NWS Forecast Office in Birmingham, Ala., for his extraordinary competence during a series of devastating tornadoes that occurred in Northern Alabama during 1973.

Patrick E. Hughes, Chief of the Publications and Media Staff in the Environmental Data Service at EDS Headquarters in Washington, D.C., for authoring scores of technical papers, popular articles, news stories, and management and program position papers that have helped define and explain EDS and NOAA scientific and technical programs, policies, plans, and services.

Bernard D. Hull, Chief of the Planning and Evaluation Branch of the Personnel Division in the Office of Administration at NOAA Headquarters in Rockville, Md., for his long and distinguished record of accomplishments in the personnel field.

Hope I. Leighton, Chief of the Publications Branch of the Solar-Terrestrial Data Services Division at EDS' National Geophysical and Solar-Terrestrial Data Center in Boulder, Colo., for her knowledge of solar-terrestrial physics together with meticulous attention to detail and adherence to high quality standards.

Herbert S. Lieb, recently appointed Director of the NWS Office of Community Preparedness at NWS Headquarters in Silver Spring, Md., and former Deputy Director of Public Affairs at NOAA's Rockville, Md., Headquarters, for his conception, supervision, and execution of NOAA public safety programs.

Harold S. McCrabb Assistant Chief of the Meteorological Services Division at the NWS Southern Region Headquarters in Fort Worth, Tex., for his part in making the NWS Southern Region's storm warning system one of the most outstanding in the Nation.

Paul L. Moore, Chief of the Scientific Services Division at the NWS Southern Region Headquarters in Fort Worth, Tex., for the numerical depiction—or digitization—of weather radar data.

John M. Robinson, Principal Assistant at the NWS Office in Cincinnati, Ohio, for his performance and timely issuance of warnings that minimized loss of life on April 3, 1974, during the violent outbreak of several tornadoes and severe thunderstorms over a large area covered by the Cincinnati radar, and for his outstanding leadership.

Alan N. Sanderson, Chief of the NWS Spaceflight Meteorology Group at the Johnson Space Center in Houston, Tex., for his outstanding leadership and initiative in guiding NWS support to spaceflight programs of the National Aeronautics and Space Administration.

Commander Donald R. Tibbit, Deputy Associate Director in the National Ocean Survey's Office of Marine Surveys and Maps at NOS Headquarters in Rockville, Md., for his outstanding leadership and service to the Nation in the development and coordination of the Southern Coastal Plains Expedition (SCOPE).

Friason G. Travis, Assistant Chief of the Aeronautical Chart Division in the NOS Office of Aeronautical Charting and Cartography, for exceptional leadership in planning and developing the Airway Fix File for the Federal Aviation Administration.

Official in Charge **Douglas L. Davis,** Principal Assistant **Wilton L. Rodgers,** and Weather Service Specialist **Thomas E. Ward,** at the NWS Office in Huntsville, Ala., for their devotion to duty and outstanding courage during the Huntsville tornado of April 3, 1974.

noaa/update

NOAA AQUANAUTS DIVE IN BALTIC

An American scientist-diver team provided by NOAA joined teams from the Federal Republic of Germany, France, and Great Britain in a three-week undersea research project in the Baltic Sea last summer.

The project undertook one scientific and two technical missions. Scientists monitored the metabolic responses and characteristics of the animal communities on the bottom, and their surrounding cold-water environment, for use in assessing the environmental health of the area.

Diver-scientists also evaluated the underwater laboratory "Helgoland," and assessed the performance of instrumentation in the cold environment.

The underwater laboratory was located about 1.5 miles (2.5 km.) offshore from the town of Niendorf at a depth of about 50 feet (15 meters). It consisted of two cylindrical sections, each with a diameter of eight feet and length of 40 feet, providing 1200 cubic feet of living and working space. The system is transportable and is towed to the operating site for deployment on the seabed.

"Helgoland" is connected by umbilical cables to a rugged surface buoy anchored nearby, which provides the power, life support, and communication facilities. Built in 1969, the system has been demonstrated in the North Sea to provide an all-weather, cold water operations capability.

U.S. Coordinator for the scientific mission was Dr. J. Morgan Wells of NOAA, who also headed the four-man U.S. aquanaut team that included William Phoel from the National Marine Fisheries Service laboratory in Sandy Hook, N.J., and Dr. Maurice Lynch and Michael Castagna of the Virginia Institute of Marine Sciences.

In addition, Dr. William J. Hargis, Jr., Director of the Virginia Institute of Marine Sciences, participated, and Commander Lawrence Bussey, USN, coordinated mission operations with the German team. Project Coordinator for the U.S. was Joseph R. Vadus of NOAA's Manned Undersea Science and Technology office.

New Planes Boost RFF Capabilities

NOAA is purchasing two new Lockheed WP-3D "Orion" aircraft, which will be operated by the Environmental Research Laboratories' Research Flight Facility in Miami, Fla.

Cost of each aircraft will be about $7 million, with research instrumentation bringing total cost to about $10 million each before the flying laboratories are operational. The First P-3 is scheduled for delivery in May 1975, the second, in January 1976. Instrumentation will be installed by the summer of 1976, when the airplanes will begin Project Stormfury, NOAA's hurricane-modification experiment.

According to ERL Director Dr. Wilmot N. Hess, the new airplanes will do much toward bringing experimental weather modification techniques to near-operational status.

"Over the past decade," he explains, "researchers in NOAA and other organizations have taken important strides toward achieving beneficial results from weather modification techniques.

"There is evidence, for example, that cloud-seeding experiments of the type used in Project Stormfury can reduce hurricane winds, and perhaps mitigate these storms' destructive effects. Our scientists in Florida are actively pursuing research to achieve the merging of cumulus cloud systems, and thereby greatly increase the efficiency of precipitation.

The airplanes will eventually replace three older research aircraft at the Miami-based Research Flight Facility, which provides aircraft support for such NOAA activities as hurricane experiments, winter storm surveillance, satellite-sensor development, and a variety of atmospheric research projects.

The P-3D is the most recent descendant of a design familiar to most air travelers as the turboprop "Electra," although the resemblance is only skin-deep. The Orion series is a tougher, more powerful airplane than its civilian ancestor, developed to carry out the U.S. Navy's anti-submarine warfare and weather reconnaissance missions.

In its NOAA configuration, the Orion lends its special capabilities to the needs of environmental research and weather modification. It will carry a flight crew of four—pilot, co-pilot, flight engineer, and navigation-communication operator—and a mission crew of twelve scientists, technicians, and observers. Seats will also be provided for five passengers.

NWS SYSTEM WARNS OF IMPENDING FLOOD

For the first time, a National Weather Service flash-flood alarm system has been used to warn of impending flooding from one of Alaska's unusual, self-dumping lakes.

The device was installed last summer below Glacier Lake on the Kenai Peninsula, south of Anchorage. It went off at 9:30 a.m., September 17, warning people in the valley below that Glacier Lake was in the process of self-dumping and that those in vulnerable localities should move to higher ground.

Most self-dumping lakes are found in the northlands. Usually, they are created by damming of tributary streams against the side of glaciers, although a few have been created by rock or mud slides. Typically, the lake is formed over a three- or four-year period during which the water gradually rises to a point where it will spill over, erode or otherwise carve a sluiceway which soon widens and drains the lake in a period of a few days.

The action is chaotic and dramatic, and the rushing water is usually filled with chunks of ice and floating debris. As much as 100,000 acre feet of icy water may be released to sweep away settlements below the spillway.

The water in the lake was 22 feet above the level at which it dumped in 1970. The Kenai River below was three to four feet above normal from recent rains. The self-dumping of the lake was forecast to cause an additional three-to-five-foot rise.

Early in July, NWS hydrologists began to issue daily flood watches, but by early August, people living on the flood plain were complaining about the constant alert.

The Alaska Disaster Office, the Corps of Engineers, the U.S. Geological Survey, and the NWS discussed the problem but saw no way to discontinue the watches until the flooding actually started. Then, NWS Regional Hydrologist Thomas J. Bowers suggested a flash-flood-alarm system be installed and the idea was unanimously approved.

On August 15, the water-level sensor was installed on the Alaska Railroad bridge crossing the Snow River, which feeds into the Kenai River. When the alarm sounded, there was ample time for people to evacuate endangered areas.

RADM SNYDER NAMED NOAA'S NAVAL DEPUTY

Rear Admiral J. Edward Snyder, Jr., has been appointed Naval Deputy to Dr. Robert M. White, NOAA Administrator.

Admiral Snyder will remain in his present position as Oceanographer of the Navy, assuming the position of Naval Deputy to the NOAA Administrator as additional Duty. He succeeds Vice Admiral William W. Behrens, Jr., who recently retired.

As Naval Deputy to Dr. White, Admiral Snyder works to foster closer accord between the Navy and NOAA in the sciences, particularly oceanography. Navy assignment to the position helps to ensure close coordination of the national oceanographic program.

Admiral Snyder has served as Oceanographer of the Navy since June, 1972. From 1963 to 1967, he served as Special Assistant to the Assistant Secretary of the Navy for Research and Development and as executive assistant to the Chairman of the Federal Interagency Committee on Oceanography. For his performance as special assistant, he was awarded the Legion of Merit for exceptionally meritorious service in the Navy and National Oceanographic Programs from 1963 to 1967. In addition, in 1967, he was awarded the Navy League's Rear Admiral W. S. Parsons Award for scientific and technical progress in Navy oceanography and for his personal contributions to the National Oceanographic Programs.

NMFS Guides Help Anglers

A geographical study of marine recreational fishing dealing with the location of fishing grounds, the various fishing and boating facilities available, local conditions and characteristics of fishing, life habits, and environmental requirement of fishes along the Atlantic coast has been published by NOAA.

The "Anglers' Guide to the United States Atlantic Coast" is issued in four sections and covers saltwater fishing from Maine to Virginia. It is authored by Bruce L. Freeman and Lionel A. Walford of the National Marine Fisheries Service laboratory at Sandy Hook, N.J.

The sections are the first half of an eight-section study now nearing completion, which will embody the entire coast from Maine to Florida.

noaa/people

Nick Kastelan, Jr., has been appointed administrative officer of the Office of Coastal Zone Management.

Leon R. LaPorte, a physical scientist with the Environmental Data Service, represented the International Coordinator for the International Cooperative Investigations of the Tropical Atlantic at the final editorial meeting for the ICITA Atlas, Volume II, Chemical and Biological Oceanography.

Joseph H. Pope, a physicist with the Environmental Research Laboratories in Boulder, Colo., was elected chairman of the Boulder Solar Energy Society for July 1974 to June 1975.

Dr. Richard Legeckis has joined the National Environmental Satellite Service oceanography research group as a National Science Foundation post-doctoral associate.

Dr. James M. Acheson has been named to the post of Social Anthropologist in the Fisheries Management Division of the National Marine Fisheries Service's Office of Resource Management.

Harry R. Spohn, who for the past six years has been Surface Observations Specialist in the DATAC Division at NWS Central Region Headquarters in Kansas City, Mo., is the new Official in Charge at the National Weather Service Office in North Platte, Nebr.

Colonel Walter Chappas, U.S. Air Force (retired) has been appointed Technical Assistant in the National Ocean Survey's Office of Aeronautical Charting and Cartography.

Paul A. Kiefer has joined the Office of the General Counsel as a Staff Attorney. His responsibilities primarily will concern National Marine Fisheries Service activities.

Thomas E. Murray has been named Assistant Program Director in the Office of Sea Grant, with special responsibilities for education and training projects.

James B. Harrison and **Francis P. Richards,** both physical scientists, have been transferred from the International Field Year for the Great Lakes Project Office to the Environmental Data Service's Center for Experiment Design and Data Analysis. Mr. Harrison is a member of the CEDDA Data Management Projects staff and Mr. Richards is with the GATE Convection Subprogram Data Center.

Robert McCaslin of the Office of Meteorological Operations Satellite Staff at National Weather Service Headquarters, has accepted a one-year assignment with the World Meteorological Organization at Tananarive, Republic of Malagasy.

Douglas R. Tranchina is the new Official in Charge at the Roswell, N. Mex., Weather Service Office.

Commander Wayne L. Mobley has been named Special Projects Manager at the National Ocean Survey's Engineering Development Laboratory in Rockville, Md.

Robert W. Huff, Chief of the Environmental Data Service's Atmospheric Sciences Library since 1970, has been reassigned to the position of Chief of EDS' Marine and Earth Sciences Library.

Merlin C. Williams, a pioneer in the field of weather modification, has been appointed Deputy Program Manager for Weather Modification at the Environmental Research Laboratories in Boulder, Colo.

Dale R. Evans has joined the Washington staff of the National Marine Fisheries Service as Chief of the Environmental Assessment Division, Office of Resource Management. He was formerly the NMFS Regional Coordinator in the Environmental Assessment Division in Alaska.

Raymond R. Waldman has been selected as Meteorologist in Charge of the Weather Service Forecast Office in Chicago. He was formerly MIC of the Weather Service Forecast Office in Milwaukee, Wis.

George T. English, jr. has been appointed to the position of Economist in the National Ocean Survey's Office of Program Development and Management.

Carol Sondheimer and **Eileen Mulaney** have been appointed by the Office of Coastal Zone Management as regional coordinators to work with State officials in managing the seashore—Ms. Sondheimer for the Southeast region, and Eileen Mulaney for the Great Lakes States.

Mike D. McKenzie has been appointed Staff Assistant in the Office of Sea Grant for institutional support programs.

Rene Cuzon du Rest, International Program Coordinator of the Environmental Data Service's National Oceanographic Data Center, has been selected for a two-year appointment to the post of Assistant Secretary for Training, Education, and Mutual Assistance in the Secretariat of the Intergovernmental Oceanographic Commission (IOC), UNESCO, Paris.

Laurence G. Shaffer has been appointed Assistant Chief of the Meteorological Services Division at National Weather Service Central Region Headquarters in Kansas City, Mo.

Commander Walter L. Bradly has succeeded Captain Steven L. Hollis in the Office of the Oceanographer of the Navy where as liaison officer, he will help coordinate related activities of the Navy and NOAA.

Jorge L. Fenucci, the recipient of an Andre Mayer FAO Research Fellowship in the field of aquaculture, will be conducting his research at the National Marine Fisheries Service Gulf Coastal Fisheries Center in Galveston, Tex.

Antonio A. Dreumont has been selected as Meteorologist in Charge of the Weather Service Office at Brownsville, Tex., where he began his career as a Meteorological Intern in 1963. He succeeded Charles H. Carpenter, who has retired.

James H. Dill has been named Meteorologist in Charge of the National Weather Service Meteorological Observatory in Pittsburgh, Pa.

Charles Kearse, Chief of the Ocean Engineering Laboratory in Miami, Fla., and Chief Engineer for the Marine Ecosystems Analysis Project, has been awarded the Colbert Award, which is presented annually to the National Ocean Survey employee judged to have contributed most to the field of ocean engineering. He was responsible for the design and shipboard integration of the current measuring systems used in the Cook Inlet (Alaska) Circulatory Survey and the data acquisition systems used in support of the New York Bight (MESA) program.

Dr. John C. Schaake, Jr., has joined the National Weather Service's Office of Hydrology as Assistant Director of the Hydrologic Research Laboratory. For the past six years he was a professor of Civil Engineering at Massachusetts Institute of Technology.

Joseph J. Borek has joined the National Ocean Survey's Office of Program Development and Management as a Program Analyst and will establish a program evaluation and monitoring system for critical major NOS projects.

Chester L. Glenn has been appointed Assistant Chief of the Meteorological Services Division at National Weather Service Western Region Headquarters in Salt Lake City, Utah.

Captain Steven L. Hollis has been named Deputy Associate Director of the National Ocean Survey's Office of Marine Technology in Rockville, Md. He formerly served as the NOAA liaison officer with the Oceanographer of the Navy.

Ed C. Higdon, who has been serving as Principal Assistant at the Daytona Beach, Fla., weather station, has been selected to be Official in Charge of the National Weather Service Office at Lovell Field in Chattanooga, Tenn.

William E. Strange, Jr. has been named Chief of the Gravity, Astronomy and Satellite Branch of the Control Network Division of the National Geodetic Survey in Rockville, Md.

George Pararas-Carayannis has assumed the post of Tsunami Specialist/Director, International Tsunami Information Center (ITIC) at the National Weather Service Pacific Region Headquarters in Honolulu, Hawaii.

Lieutenant Russell C. Arnold has been named Chief of National Geodetic Survey Party G-20.

Leighton L. Schneider is the new Official in Charge of the National Weather Service Office in Dubuque, Iowa.

Commander Robert A. Ganse has been appointed Commanding Officer of the NOAA Ships *Rude* and *Heck*.

Dr. Glenn A. Flittner has been appointed Chief of the Ocean Services Division in the National Weather Service Office of Meteorology and Oceanography. He succeeds Dr. William H. Quinn, who returned to Oregon State University at Corvallis last year.

Commander Joseph W. Dropp has been appointed Commanding Officer of the NOAA Ship *Peirce*.

Lieutenant Commander John D. Stachelhaus and **Lieutenant Commander Michael Kawka** have been named Commanding Officer and Executive Officer, respectively, of the NOAA Ship *George B. Kelez*.

Wilvan G. Van Campen, a former State Department Foreign Service Officer with wide experience in fisheries matters, has been named to coordinate National Marine Fisheries Service activities with the Pacific Tuna Development Foundation.

Harvey R. Bullis, Jr., Director of the National Marine Fisheries Service Southeast Fisheries Center in Miami, Fla., now has named after him four species (plus one genus) of teleost fish, three gastropod mollusks, two starfish, and one species each of shark, skate, squid, bivalve mollusk and crab.

Lieutenant (junior grade) Stephen J. Kott is at the South Pole, where he has taken charge of the NOAA program. He was previously assigned to the Air Resources Laboratories in Boulder, Colo., in preparation for his duties in Antarctica.

NACOA Urges More Emphasis On Climate, Energy

The United States must intensify its efforts to cope with the influence of climate on food production and energy use in a two-pronged attack, the National Advisory Committee on Oceans and Atmosphere urged in its annual Report to the President and Congress on the nation's marine and atmospheric affairs.

"The ability to sustain our economy in the face of the fuel shortage this last winter, with only minor discomforts as a nation," the Committee said, "was due largely to a spell of warm winter weather in the United States. What luck next time?"

Each year NACOA reports on several major topics of current importance. This year most of the topics chosen bear on the switch from a sense of self-sufficiency in natural resources to anxiety about their use. Law-of-the-Sea, Weather Modification, Coastal Zone Management, Federal organization for marine affairs, and greater support for the U.S. Coast Guard are among the subjects discussed.

Because climate is key in its effect on food production and energy consumption, NACOA urges a concerted effort to use now what we already know about climate to help mitigate its harmful effects. The Committee recommends that we extend our projections of climatic effects three to five years into the future, estimate what food and energy problems might then occur, and give ourselves the time to plan accordingly.

At the same time NACOA urges that we learn more about what causes climate to change and what effect man's activities might have on climate. We could then work to lessen man's influence on climate or even, perhaps, use it beneficially. This requires a more centrally focused scientific effort than now occurs, NACOA says, and suggests that the National Science Foundation and NOAA collaborate in an emphasis on air-sea interaction

In a chapter entitled, "After Caracas/Vienna, What?" the Committee says that the United States must increase its efforts to prepare for the several possible outcomes of the Law-of-the- Sea Conference.

Created by Congress in 1971, the 25-member Advisory Committee is drawn from widely diverse non-Federal activities related to the sea and air environments. Dr. William A. Nierenberg, Director of the Scripps Institution of Oceanography, is Chairman

Announce NOAA, EEO Award Winners

Five NOAA employees received 1974 NOAA Awards and two were recognized for outstanding achievement in NOAA's Equal Employment Opportunity program.

Recipients of the $1,000 NOAA Awards were:

—**Dr. Douglas H. Sargeant** of NOAA's headquarters in Rockville, Md., Director of the U.S. Project Office of GATE—the Atlantic Tropical Experiment of the Global Atmospheric Research Project—for Program Administration and Management;

—**Robert E. Johnson,** Chief, Systems Integration Division, Systems Development Office, National Weather Service, Silver Spring, Md., for Engineering and Applications Development;

—**Dr. Donald J. Williams,** Director of the Boulder, Colo.-based Environmental Research Laboratories' Space Environment Laboratory, for scientific Research and Achievement;

—**Joseph Dracup,** Supervisory Geodesist of the National Geodetic Survey in Rockville, Md., for Public Service; and

—**Burton L. Tinker,** Food Technologist at the Northeast Utilization Research Center of the National Marine Fisheries Service, Gloucester, Mass., for Public Service.

Receiving $500 NOAA Equal Employment Opportunity Awards were NOAA Assistant Administrator for Administration **Theodore P. Gleiter** and **Mrs. Jacqueline A. Colt,** an Administrative Assistant at the National Marine Fisheries Service's Southwest Fisheries Center in La Jolla, Calif.

Dr. Sargeant has directed U.S. preparations for and participation in GATE, the field phase of which was recently completed off Senegal, Africa. The experiment involved approximately 4,000 persons from 70 nations, and a wide array of satellites, aircraft, ships and other platforms. Dr. Sargeant, more than any other individual, has comtributed to the highly successful execution of the observational phase of the GATE program. His resourceful management helped overcome threatened loss of vital satellite information and other equipment difficulties.

Mr. Johnson, affiliated with the NWS since 1966, has pioneered in the application of modern engineering technology to field operations. In 1971, he led in analyzing these operations in terms of their suitability for automation. From his efforts came the NWS' recently-unveiled Automation of Field Operations and Services (AFOS) Program, designed to speed and improve weather forecasts and warnings. He directed the development of an experimental model AFOS station.

Dr. Williams, Director of the Space Environment Laboratory since 1970, has organized the best magnetospheric and one of the best interplanetary medium research groups in the United States. An expert in the dynamics of magnetospheric particle populations, he was instrumental in developing detectors for the measurement of ions and electrons at very low energies, and has used the instrumentation of 12 satellites to map the magnetosphere's charged-particle population

Mr. Dracup for many years has devoted much of his own time to helping surveyors through the transition to modern methods that use NOAA's products and services. He has organized and participated in many workshops, usually on weekends, instructing surveyors in modern methods. Federal, state, and local surveyors have been assisted by these efforts.

Mr. Tinker, in 1970, began counseling a New Bedford, Mass., minority group interested in processing red crab, and underutilized shellfish. His technical assistance included aid in the preparation of proposals and plant design requirements. The group, which eventually became the New Bedford Atlantic Associates, received an Economic Development Administration grant in 1972 to undertake a pilot project. In 1973, Atlantic Associates materially expanded operations and on August 30, 1974, broke ground for a new plant in New Bedford. Mr. Tinker's assistance—much of it in off-duty hours—contributed significantly to the success of the venture.

Mr. Gleiter has been cited for continuing aggressive and imaginative leadership in all aspects of EEO. He has pointed out areas in employment where minorities and women tend to be locked into dead-end jobs, and has sponsored and encouraged a number of upward mobility programs to enable lower level employees to enter new careers. He has assured that his own division has increased its number of minorities and women at higher grade levels.

Mrs. Colt was recognized for "exceptional initiative and effort in encouraging the employment of handicapped individuals." She was instrumental in the recruitment of several severely handicapped individuals at the center, and has also contributed to EEO progress in the employment of minority and female candidates at the center, contacting and working with the Neighborhood Youth Corps, Work Incentive Program, Urban League, summer aid program, Upward Bound groups and others.

NOS Units Complete Surveys

The National Ocean Survey has announced completion of a nautical charting survey of a corridor through Prince William Sound leading to Valdez, terminus of the Alaska oil pipeline. The NOAA Ship *Davidson,* under the command of Commander Michael H. Fleming, conducted the survey along the proposed oil tanker route to the southern Alaskan community.

The National Geodetic Survey has announced completion of the following projects:

A six-year geodetic survey of Louisiana, covering more than 17,000 square miles. The survey, a long-range cooperative program carried out since 1968 by the NGS and the State, was needed because of rapidly rising land values. The last leg of the survey, a nine-month survey in the southwestern part of the State, was completed by the 26-man field party headed by Harry R. Romine.

A geodetic survey in New York State along a 25-mile route from Yonkers to Battery Park to the Brooklyn Bridge, conducted by the 15-man leveling party headed by Jame W. Taylor.

A geodetic survey in New Jersey and Pennsylvania along an 80-mile route extending from South Amboy to Philadelphia via Trenton and the Camden area, also performed by Mr. Taylor's field party.

Projects underway by the NGS include:

A geodetic survey along more than 130 miles of Interstate Highway 95, being conducted by the NGS and the State of Maine. The survey, being carried out by a cooperative surveying team headed by Lieutenant Russell C. Arnold, is expected to take eight months

A two-month survey of the force of gravity at 800 points along a 300-mile line in six California counties, being made by Lieutenant Steven R. Birkey and Charles M. Bergmann.

A five-month geodetic survey of more than 760 miles in 30 counties in New Mexico and Texas being made by the 18-man field party headed by Ivan R. Crabbe and the 20-man party headed by James L. Cook. Preliminary field work for the project was conducted by surveying technicians Charles R. Lesley and Wesley O. Means.

Units Cited For Excellence

NOAA Unit Citations were awarded at the 1974 Awards Luncheon, to groups of NOAA employees whose individual and collective efforts resulted in substantive contributions to the programs or objectives for which NOAA was established.

Dr. Robert M. White, NOAA Administrator, presented the citations.

For the combination of skill and dedication to duty displayed in the National Weather Service on April 3 and 4 of 1974, when 90 tornadoes struck the midsection of the United States (the forecasts and warnings were outstanding, and many NWS people worked in the face of danger to their lives), Unit Citations were awarded to:

The Weather Service Forecast Offices in
—Atlanta, Ga.;
—Lousville, Ky.;
—Birmingham, Ala.;
—Indianapolis, Ind.;
—St. Louis, Mo.; and
—Detroit, Mich.

The Weather Service Meteorological Observatories in
—Old Hickory, Tenn.;
—Birmingham, Ala.; and
—Centreville, Ala.

The Weather Service Offices in
—Cincinnati, Ohio;
—Nashville, Tenn.;
—Chattanooga, Tenn.;
—Athens, Ga.;
—Lexington, Ky.;
—Evansville, Ind.;
—Ft. Wayne, Ind.;
—Springfield, Ill.;
—Lansing, Mich.;
—Dayton, Ohio; and
—Huntsville, Ala.

—And to the National Severe Storms Forecast Center at Kansas City, Mo., for its exceptional performance in supporting the frontline stations, which helped make possible the saving of life on such a large scale.

National Ocean Survey recipients were:

—The New Datum Section in the Horizontal Network Branch of the Control Network Division, of the National Geodetic Survey, for significant progress toward the new adjustment of the North American Datum in a year of changes in computer programming and traditional practices.

—The Marine Field Support Group of the Scientific Services Division in the Office of Program Development and Management, for effectively supporting and improving the software of the 15 hydroplot-hydrolog systems on NOAA's hydrographic survey vessels.

—The Mobile Calibration Laboratory in the National Oceanographic Instrumentation Center of the Office of Marine Technology, for development and operation of the first sophisticated movable facility of its kind for servicing the broad range of oceanographic instruments used in the Marine Ecosystems Analysis program.

National Environmental Satellite Service recipients were:

—The Supervisors in the Geostationary Spacecraft Support Section at the Command and Data Acquisition Station on Wallops Island, Va., for outstanding accomplishment in ensuring the operational readiness of equipment and systems used to support the SMS-A spacecraft.

—The Office of System Engineering, for establishing the SMS ground system, a task requiring a new level of sophistication in satellite data handling, dissemination and display.

Environmental Data Service recipients were:

—The Systems Branch of the Technical Information Division of the Environmental Science Information Center, for outstanding work in conversion of the Oceanic and Atmospheric Scientific Information System to a fully operational program.

—The ENDEX Task Team, in recognition of its essential contributions to the development of an operational Environmental Data Index, a computerized, interdisciplinary system providing referral to historical, environmental data files.

NOAA Headquarters recipients, from the Office of the Assistant Administrator for Administration, were:

—The Servicing Personnel Officers in the Operations Branch of the Personnel Division, for significantly improving personnel management services to NOAA components.

The Environmental Research Laboratories unit recognized was:

—The Space Environment Services Center of the Space Environment Laboratory, in Boulder, Colo., for outstanding contributions of space environment support to the Skylab mission. This Center's performance was an excellent example of the operational use of space weather services.

Recognized from the National Marine Fisheries Service were:

—Personnel of the Southeast Fisheries Center in Miami, Fla., and its facilities in Pascagoula and Bay St. Louis, Miss., who participated in the Skylab Oceanic Gamefish Experiment. In cooperation with NASA, employees at the Center planned and carried out this unusual experiment, involving more than 114 fishing vessels and 10 oceanographic ships.

EDS Releases Pollution Data

Environmental data from a study to assess the potential effects of man-generated substances and activities on the marine environment is now available from the Environmental Data Service.

The data are from the Prediction of Ocean Pollutants Study conducted by the Ocean Affairs Board of the National Research Council which began in May 1973 with the identification of six substance types for study.

The substances, chosen because of their persistence, toxicity, and abundance in the marine environment, include nuclear wastes, synthetic organic chemicals, marine litter, metallic processing wastes from industrial operations, organic sludges, and medical and agricultural pharmaceuticals.

Information on each substance's basic chemical and physical properties, U.S. and foreign production, major uses, environmental leakages, routes through the environment, and potential effects on the environment was collected by ten NRC research associates during the summer of 1973.

LEAGUE HONORS DAVID JOHNSON

David S. Johnson, Director of the National Environmental Satellite Service, a pioneer in the development and use of satellites for improved weather forecasting, was honored as one of eleven top Federal career employees, when the National Civil Service League presented him with a Career Service Award.

Mr. Johnson was selected for the award in recognition of his distinguished career focussed on the design and development of systems for using satellites to provide timely and accurate information on worldwide weather patterns and movements, enabling meteorologists to provide more timely storm warnings and accurate forecasts.

Correction

An explanatory line was omitted accidentally under a chart headed *U.S. Fish Catch* on page 60 of the October, 1974 issue of NOAA. The chart should have stated that the figures were in "thousands of pounds."

Dent Names Fifteen As Advisors

Secretary of Commerce Frederick B. Dent has announced the appointment of fifteen members of the newly formed Marine Petroleum and Minerals Advisory Committee.

The purpose of the Committee is to advise the Secretary of Commerce on matters pertinent to the Department's responsibilities related to marine petroleum and marine minerals resources, on means to facilitate cooperation between the private sectors and government in these matters, and on related Law of the Sea affairs.

Members appointed are:

—Dr. Thomas D. Barrow, Director and Senior Vice President, Exxon Corporation, U.S.A., New York, N.Y.

—Herbert Brand, President of the Transportation Institute, Washington, D.C.

—Dr. Dayton Clewell, Senior Vice President for Research and Engineering of the Mobil Oil Corporation, New York, N.Y.

—Marne A. Dubs, Director of Ocean Resources, Kennecott Copper Corporation, New York, N.Y.

—John E. Flipse, President of Deepsea Ventures, Inc., Glouster Point, Va.

—Ben C. Gerwick, Jr., Professor of Civil Engineering at the University of California, Berkeley, Calif.

—Leon Hess, Chairman of the Board of Directors and Executive Officer of the Amerada Hess Corporation, New York, N.Y.

—Edward Hood, President and Chairman of the Board of Directors of the Shipbuilders Council of America, Washington, D.C.

—Thomas L. Kimball, Executive Vice President of the National Wildlife Federation, Washington, D.C.

—Betty N. MacDonald of Madison, Wis.

—Robert Mauermann, Executive Secretary of the Texas Shrimp Association, Brownsville, Tex.

—Cecil J. Olmstead, Vice President of TEXACO, Inc., New York, N.Y.

—Melvin N. A. Peterson, Principal Investigator and Project Manager of the Deep Sea Drilling Project, Scripps Institution of Oceanography, LaJolla, Calif.

—John G. Winger, Vice President-Energy Economics Division of the Chase Manhattan Bank, New York, N.Y.

—Robert B. Ziegler, Vice President of the IHC Holland Dredging Division, Mystic, Conn.

noaa/update

NMFS, States Plan Fisheries Rehabilitation

NOAA, in cooperation with State Governments, is developing a plan aimed at rehabilitating U.S. marine fisheries, many of which are suffering from the effects of heavy fishing by foreign fleets as well as from depleted stocks and environmental changes. Preparation of a National Fisheries Plan was recommended recently by the President's National Advisory Committee on Oceans and Atmosphere, and the National Marine Fisheries Service was assigned the task.

A draft outline of a plan has been completed by a task force and will be used to review the needs of the fisheries with various interested people in and out of government. The outline describes the present problems facing U.S. fisheries and discusses a series of major issues of primary concern in any effort to meet our national purposes in fisheries if they are to provide employment, food, and recreation. The outline also reviews how the issues involved can be applied in formulating a viable National Plan.

Fletcher is ERL Deputy; Established Ice Island

Joseph O. Fletcher, who since 1971, as Director of the National Science Foundation's Office of Polar Programs, has planned, organized, and conducted research projects in the Arctic and Antarctic, is the new Deputy Director of the Environmental Research Laboratories.

While at NSF, Mr. Fletcher led efforts for establishment last May of a new Office for Climate Dynamics, which he headed, and formulation of a long-term research program in climate dynamics.

Before joining NSF, he was Research Professor of Atmospheric Sciences and Oceanography at the University of Washington, and director of the university's polar research programs.

He directed geophysical research at the Air Force's Cambridge Research Laboratories and headed the Long Range Plans Group attached to Air Force Headquarters. In 1952, he led the expedition that established a research station on a massive chunk of drifting ice in the Arctic Ocean known as T-3, or Fletcher's Ice Island, which still serves as an important base for meteorological, oceanographic, and other research.

Dale Gough Heads NASO

Dale C. Gough has been appointed director of NOAA's Northwest Administrative Services Office. The Seattle, Wash., facility was formerly headed by John M. Patton, Jr., who recently retired.

For the past seven years, Mr. Gough has been the personnel officer for NOAA's Environmental Research Laboratories in Boulder, Colo., which provides personnel services for the Commerce Department's National Bureau of Standards, the Office of Telecommunication Services, and NOAA elements in the area.

Arnold Hull Is Deputy EDS Head

Arnold R. Hull has been appointed Deputy Director of the Environmental Data Service. He joined the EDS staff in 1971 as Associate Director for Climatology.

As Deputy Director, Mr. Hull shares with the Director responsibility for planning, developing, coordinating, and administering EDS's diverse system of data centers—the National Climatic Center, National Oceanographic Data Center, National Geophysical and Solar-Terrestrial Data Center, Center for Experiment Design and Data Analysis, and Environmental Science Information Center, as well as the Center for Climatic and Environmental Assessment and National Oceanographic and Atmospheric Satellite Data unit—two new specialized EDS activities soon to be activated.

LSC Establishes A Marine Base

NOAA has established a small marine base at Monroe, Mich., to provide a centralized location for the maintenance and operation of its Great Lakes vessels.

The vessels—the 65-foot, 90-ton *Shenehon*, the 54-foot, 20-ton *Laidly* and the 50-foot, 20-ton *Johnson*—are operated by the Lake Survey Center, the Detroit-based unit of the National Ocean Survey. The marine base will accommodate smaller 17-to-24-foot craft which supplement the work of the larger ships.

The new marine base will also house the LSC's marine equipment, cars, trucks, and office trailers.

The base is located at the extreme west end of Lake Erie near the mouth of the Detroit River, adjacent to the Port of Monroe turning basin on the Raisin River.

WHITE RECEIVES TOP PUBLIC SERVICE HONOR

NOAA Administrator Dr. Robert M. White has received the 1974 Rockefeller Public Service Award for the Development and Protection of Physical Resources from President Ford.

The Rockefeller Public Service Awards are the most prestigious honors given annually to federal career officials.

In his 24 years of federal service White has served four presidents. President Kennedy appointed him Chief of the U.S. Weather Bureau in 1963. When President Johnson established the Environmental Science Services Administration (ESSA) in 1965, he named White to head it; President Nixon named him Administrator of NOAA when it was founded, in 1970.

Dr. White is the recipient of many science and engineering honors. He is a member of the National Academy of Engineering. He received the Rosenberger Medal from the University of Chicago in 1970 for outstanding contributions to the field of geophysics; the Godfrey L. Cabot Award for outstanding contributions to aeronautics through the field of graphic and Meteorological Labo-Abbe Award of the American Meteorological Society for contributions to that organization's work.

ERL STUDIES ROLE OF ATMOSPHERIC SOLIDS

Two Environmental Research Laboratories scientists have calculated the effects of earth's high points—the Rocky Mountains, the Andes, the Tibetan Plateau, Greenland, and Antarctica—on the general circulation of the atmosphere.

Dr. Syukuro Manabe and Theodore B. Terpstra of the Geophysical Fluid Dynamics Laboratory in Princeton, N.J., calculated the circulation patterns for two different hypothetical earths, a smooth earth, where the main influence on circulation is radiative heating and cooling, and a bumpy earth, where the effects of mountains are also taken into account. The two results were compared with "real life" circulation as actually observed.

They found that the wind patterns that resulted from the mountainous earth model more closely matched reality than those of a billiard-ball earth. But mountains exert their influence upwards, affecting the upper troposphere and the stratosphere more than the layers of the atmosphere closest to earth. At the lower levels, thermal effects dominate.

The calculations show, for example, that stationary troughs, or areas of low atmospheric pressure, lie in the lee of major mountain ranges such as the Rocky Mountains and the Tibetan Plateau, which includes the Himalayas.

One of the main features of the atmospheric flow pattern over Eurasia is an anticyclone—a closed circulation system flowing in a clockwise direction that produces a high-pressure area over Siberia. The NOAA computer simulations showed that the Tibetian Plateau shoves the anti-cyclone northward and intensifies it. "In other words, it plays a very important role for the maintenance of the Siberian high," note the researchers. On the other hand, an intense stationary cyclone over the Aleutians seems to exist with no help from neighboring mountains.

On the whole, cyclones, the large-scale circular patterns that produce atmospheric "lows", tend to form on the leeward side of major mountain ranges. Such cyclones are often accompanied by inclement or even destructive weather.

In the southern hemisphere, where there are few large mountain ranges to interrupt the flow, the atmospheric motion tends to follow paths more nearly paralleling the equator than in the northern hemisphere.

ABRAMSON DIRECTS NMFS TIBURON LAB

Norman J. Abramson has been named Director of the Tiburon, Calif., Laboratory of the National Marine Fisheries Service Southwest Fisheries Center. Since April 1972 he has led an investigation on fisheries resource assessment and utilization at the Laboratory. Previously he headed the sportfish statistics program of the NMFS Statistics and Market News Division.

He first worked as a deck hand and skipper on sportfishing boats in California, then was a commercial fisherman, and then a crew member on a fish patrol boat for the California Department of Fish and Game.

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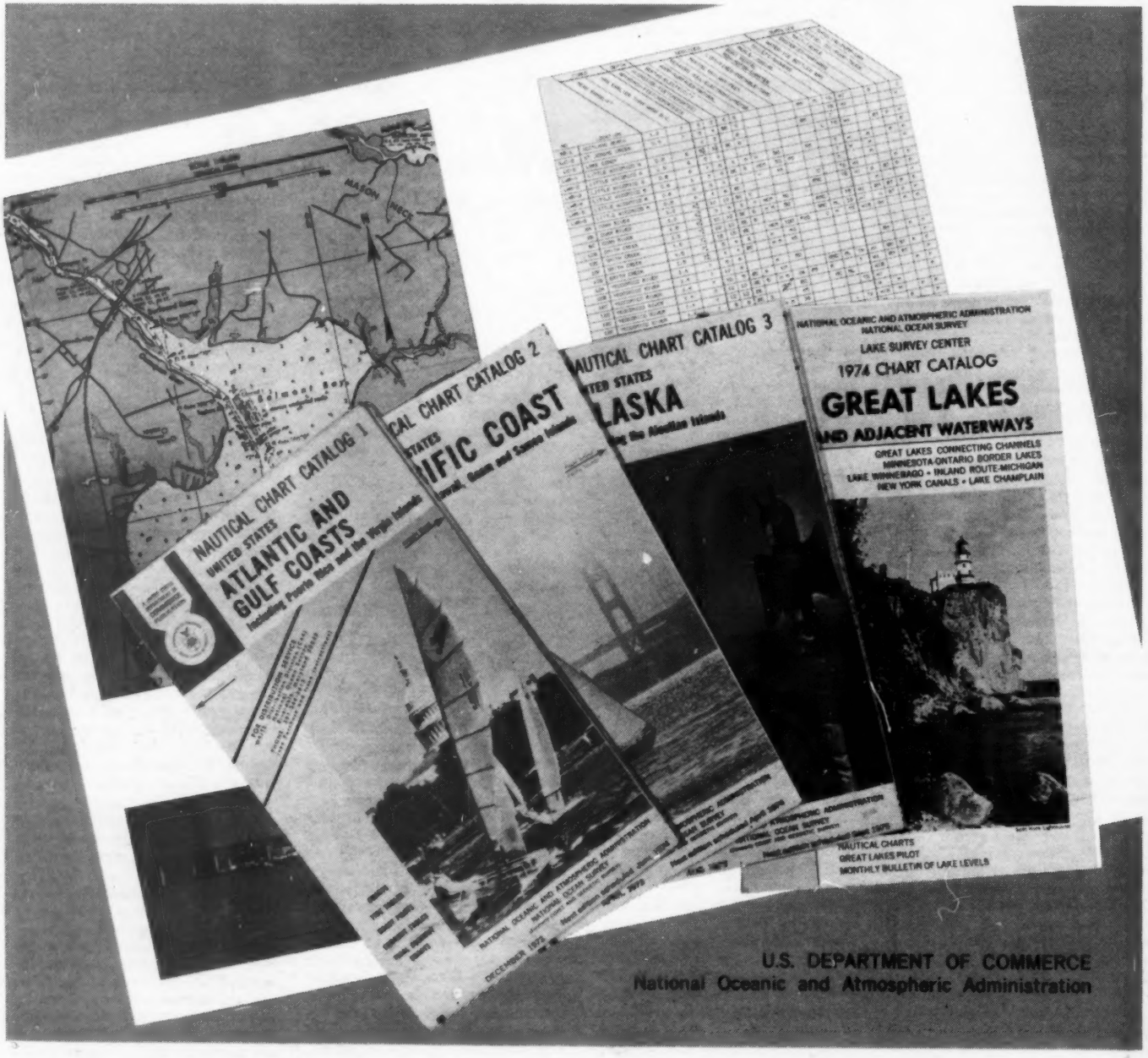

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